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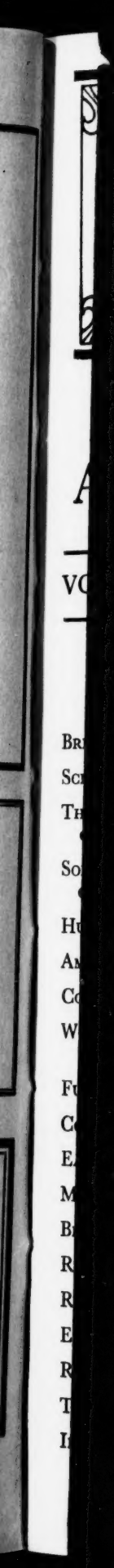

THE ADVANCEMENT OF SCIENCE

VOL. V, No. 20 JANUARY, 1949

CONTENTS

PAGE

BRIGHTON MEETING, 1948 283

SCIENCE AND PHILOSOPHY, *by* THE RT. HON. VISCOUNT SAMUEL, G.C.B., G.B.E., D.C.L. 287

THE INFLUENCE OF FORESTRY ON THE COMMUNITY, *by* W. L. TAYLOR, C.B.E., AND OTHERS 293

SOME BIOLOGICAL ASPECTS OF COLONIAL DEVELOPMENT, *by* SIR FRANK STOCKDALE, G.C.M.G., C.B.E. 300

HUMAN BLOOD-GROUPS, *edited by* PROF. K. MATHER 305

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE 316

CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES 317

WORLD FAT SUPPLIES IN RELATION TO THE NEEDS OF GREAT BRITAIN AND THE COMMONWEALTH, *by* PROF. T. P. HILDITCH, F.R.S. 322

FUNGI AND THEIR ECONOMIC IMPORTANCE, *by* PROF. F. T. BROOKS, C.B.E., F.R.S. 329

CONSERVATION OF THE CHEMICAL ELEMENTS, *by* PROF. J. D. BERNAL, F.R.S., AND OTHERS 335

EARLY MIOCENE APES FROM EAST AFRICA, *by* PROF. W. E. LE GROS CLARK, F.R.S. 340

MATHEMATICAL TABLES 341

BRIGHTON MEETING 1948 : SECTIONAL TRANSACTIONS 348

REFERENCES TO PUBLICATION OF COMMUNICATIONS TO THE SECTIONS 353

RESEARCH COMMITTEES, 1948–49 355

EXPLORATION OF CAVES IN THE DERBYSHIRE DISTRICT 356

REPORT OF COUNCIL, 1947–48 358

TREASURER'S REPORT, 1947–48 364

INDEX TO VOL. V 373

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BRIGHTON MEETING, 1948

THE 110th (and second post-war) Annual Meeting of the Association was held from September 8 to September 15 in Brighton, where the Association had previously held only one meeting, in 1872. With the exception of Sunday, September 12, when the area was swept with high wind and drenching rain, the meeting was favoured with bright September days.

Accommodation for thirteen Sections plus subsections and other divisions (over 30 lecture and other meeting rooms) was provided in five centres, the Royal Pavilion Estate, Technical College, College of Art, Brighton College and Training College. The Headquarters, consisting of reception room, public rooms and administrative offices, were located in the Royal Pavilion (which also housed five sections) and social functions were held in the Dome, in the Corn Exchange and in hotels. The Royal Pavilion also accommodated the Press Bureau, and radio broadcasting was organised from the Technical College. Exhibitions and demonstrations were displayed in the Corn Exchange, in the Corporation's Art Gallery, in rooms at the Pavilion and at the Technical College.

Excursions, of which there were 60, with places for 2,700 people, were organised by local volunteers in co-operation with the Southdown Bus Company. With a few exceptions they began and ended at the Royal Pavilion Estate which was a convenient central point with adequate room for marshalling.

The registered attendance at the meeting was approximately 1,800, as compared with a normal average of 2,500 for the British Isles as a whole, 1,750 for five meetings on the South Coast, and 3,250 at the first post-war meeting, held in Dundee. The number of local members was not more than 150 (as compared with 1,750 at Dundee) and the lack of local interest by the public was further shown by a complete absence of demand for public lectures from any centre of population in Sussex. The Association was, nevertheless, generously entertained by the Mayor and Corporation of Brighton, the work of organisation was ably assisted by local volunteers, and the members also enjoyed kind hospitality on excursions and visits.

The meetings were well reported in the press, by broadcasts, and in technical journals. It has never been practicable to publish a full record of the formal proceedings of an Annual Meeting during which it has been estimated that some 300 speakers talk for 200 hours : nor would it be desirable to do so. The October issue of *Discovery* contained a supplement on the Brighton meeting which can be recommended as a useful summary of the more important items ; and the Editors of *Nature* have given generously of their limited space during the past four months for general reports of major discussions. The October number of *The Advancement of Science* contained all the Presidential Addresses in full, the present number contains other material together with a record of the transactions (page 348) and a list of references (page 353) to publication elsewhere as supplied by authors. The next two numbers will contain further reports on the proceedings. The following notes may serve as a permanent outline record of the meeting.

Wednesday, September 8.

The Council and General Committee met in the afternoon in the Royal Pavilion. The General Committee received and approved reports on the preceding year from the Council (page 359) and on the financial year from the Treasurer (page 365). Sir John Russell, O.B.E., F.R.S., was elected President for 1949 (Newcastle meeting).

The Inaugural General Meeting was held in the Dome at 8.30 P.M. when the Mayor of Brighton officially welcomed the Association to Brighton and Sir Henry Tizard, K.C.B., F.R.S., delivered his Presidential Address on ' The Passing World.'

The President invited his audience to turn their eyes on the passing world, a world which was moving from one state of unstable equilibrium to another. He said that if the equilibrium must be unstable for many years to come, science could contribute much towards making it more stable, and in considering what science could reasonably be expected to contribute to this aim, it was necessary to have both a backsight, consisting of the history of the progress of science, and a foresight fashioned from our knowledge of the state of science to-day and from what we knew to be possible. The first part of the address was a broad review of the progress of science from about 1885, the year of his birth and the year which almost marked the end of a stagnant period of nineteenth-century science. The main part of the Address has been described by one commentator as essentially a sermon on economic recovery, and the balance to which the President addressed himself was the balance between the pursuit of science and the applications of science. In his view one of the main lessons to be learnt from history of the past two generations was that the supremacy of Britain in the nineteenth century and later had been derived mainly from inventiveness and engineering genius and that only by maintaining leadership in the application of science could Britain hope to keep a position among the great nations. While paying just tribute to the high quality of the reserve of scientific ability directed

to scientific investigation, and after emphasising the importance of maintaining the quality of original research, the President said he believed that no new discovery was likely to have so quick and beneficial an effect on British industry as the application of the vast amount of knowledge waiting to be used. What was of first importance was to apply what was already known. In the field of public health the same thing was true, as it was also in the field of agriculture, and in dealing with those subjects the President said that whatever comforts and luxuries might be provided in future by the advance of physical science, it was on the development of the biological sciences that the peace and prosperity of the world would largely depend. In conclusion, the President said that, difficult though the times were, they were also very interesting and bracing to a nation which had not lost the resilience of youth. The present was a time for adventure, for the taking of risks which were calculated but not so nicely or so lengthily calculated that they were taken too late.

At the close of the address Sir John Russell, President-Elect, proposed a vote of thanks.

Thursday, September 9.

The thirteen Sections began their programmes simultaneously at 10 A.M., and in the course of the morning the addresses of five of the Sectional Presidents were delivered. Prof. H. Graham Cannon spoke on 'Undergraduate Zoology' and his address was followed by a series of papers on functional morphology. Wing-Commander T. R. Cave-Browne-Cave read an address on 'The Young Engineer,' which was followed by a discussion of his analysis of the qualities required to make a successful engineer, and the training he should be given. (In response to public demand this address and a report of the discussion have been reprinted and copies are available from the Office, price 6d.) Mr. R. U. Sayce addressed his Section on 'Folk-life Studies in Britain and Abroad.' Prof. Rex Knight reviewed 'Present-day trends in British psychology'; Prof. J. R. Matthews delivered an address on 'The study of the British Flora.' In his absence through serious illness, which proved fatal before the end of the year, Dr. G. Scott Robertson's address to the Section of Agriculture on 'Maintenance of the World food supply' was read by Prof. R. G. Baskett. Dr. Robertson's address was followed by a discussion with the Chemistry Section on the same subject, in which Sir John Russell spoke on Britain's part in the world food problem and Prof. T. P. Hilditch dealt with world fat supplies in relation to the needs of Great Britain and the Commonwealth (see page 323).

After some difficulties with their projection equipment had been overcome, the Physics Section received two groups of papers on the physics of coastal waves and on cosmic magnestism. The Geology Section received papers on local geology and one on dowsing, which induced lively discussion. Like the geologists, the Geography Section opened their programme with papers on local geography. The Economists discussed building materials and industrial productivity. In the Anthropology Section Prof. Le Gros Clark described important remains of fossil apes recently found in Kenya (see page 340). Physiologists had a discussion on changing aspects of nutrition, in which Prof. A. Fleisch, President of the Swiss Federal Commission for Nutrition, reported the results of an experiment on four million people. As a result of changing Switzerland's food production from meat and fats to vegetables and fruits, there were no queues, the people were healthier and their weight and capacity for work were improved. He expressed the view that 2,160 calories per day was a sufficient minimum for adults as compared with 2,400 calories advocated by the United Nations as a health minimum. The Education Section discussed Aspects of World Education. In the afternoon Prof. H. J. Fleure delivered the Presidential Address to the Conference of Delegates of Corresponding Societies (see page 317), and other afternoon sessions included one in which Sir Henry Dale and other eminent physiologists reviewed the state of knowledge on the transmission of effects from the endings of nerve fibres.

In the evening on Thursday, Prof. S. W. Wooldridge gave a discourse on The Weald and the Progress of the Field Sciences, the Music Room at the Pavilion being filled to capacity. The discourse gave an appropriate introduction to the district which was to be visited by so many parties later in the week.

Friday, September 10.

Four Presidential Addresses were read in the course of the morning. Sir Lawrence Bragg's address was a 'Review of recent advances in the study of the crystalline state' and seems likely to become a standard work of reference. Lord Rennell of Rodd spoke on 'Geography as a social science with a special reference to Africa'; Sir Hubert Henderson addressed the Economics Section on 'The price system' and Mr. W. O. Lester Smith spoke on 'The changing scope of education.'

The Sectional programmes included the following principal items. The Physics Section had a symposium at which some of the crystallographers, mentioned by Sir Lawrence Bragg, including Mrs. Hodgkin and Mrs. Lonsdale, described their work in more detail. The Chemistry Section received a series of papers on newer metals and alloys, the Geology Section discussed air photographs, the Section of Zoology biological aspects of Colonial development, the opening contribution being made by Sir Frank Stockdale. At the same time, unfortunately, and this was one of the few serious clashes of interest which it was impossible to avoid, the Geography Section discussed the wider question of scientific aspects of Colonial development.

The Engineering Section had a discussion on the Metric System, in which widely divergent views were expressed on the desirability of its universal adoption. One apparently devastating argument against this measure was that in Anglo-Saxon countries, where the inch and the pound were used, the volume of industrial production in certain fields of manufacture was more than twice as great as that from the rest of the world. Considering all the equipment, standardisation, spare-part stock and handicraft which had contributed to this superiority, the universal adoption of the metric system appeared to be impracticable and unreasonable. The Physiology Section's meeting room was filled to overflowing with an audience, of which the average age was said to be distinctly high, for a discussion with the Psychology Section on problems of old age. The introductory remarks of Sir E. Rock Carling have been widely quoted. He said that only one in thirty over the age of 60 was ailing and decrepit, that there was no scientific warrant for a fixed retiring age and that both the economic needs of the country and the harmful effects of ceasing work, supported a continuance of work as far as possible. He said it was time for the elderly to revolt against conventional pressure to retire at 60 or 65. In the Education Section, the Presidential Address was followed by a discussion on the administrator and the teacher, and the Section of Agriculture joined with representatives from the Sections of Zoology and Botany for a discussion on inbreeding and hybrid vigour in livestock and crop improvement.

In the evening the Mayor and Corporation entertained the members at a Civic Reception. Guests were received in the Corn Exchange by the Mayor, who was accompanied by the President and Lady Tizard. There was dancing for 500, to two orchestras, in the Royal Pavilion and the remainder were entertained to a concert in the Dome. Refreshments were served during the evening in the Corn Exchange and in the Royal Pavilion.

Saturday, September 11.

During the day most members took part in general and sectional excursions. In the morning there were two showings of the Gaumont-British (Instructional) sound film on Atomic Physics and in the evening the Division for Social and International Relations of Science held a session, in the Dome, on 'Science across the frontiers.' This meeting was open to the public and was attended by about 700 people. Dr. C. H. Desch presided and Dr. Julian Huxley, then Director-General of UNESCO, was the opening speaker.

Dr. Huxley described UNESCO as the only international organisation dealing with all the higher activities of the mind. He said that its deepest function was to help to reunite harmoniously the diverging and disintegrating tendencies of the human mind and that this function might be achieved by working for a world civilisation which existed only in embryo at the present time.

He was followed by Dr. Joseph Needham, formerly head of the Science Department of UNESCO, who outlined the historical development of international co-operation in science and described the beginnings of UNESCO's work in science as the integration of war-time liaison with established international Unions.

Prof. Pierre Auger, successor to Dr. Needham as head of the Science Department, described the work of his Department whose main task was pioneering new fields of international co-operation. He described this task as doing very much with very little. The aim of the Department was to discover by intelligence the desire and the need for international scientific action and to facilitate that action, and he compared this function with catalysis in which large chemical changes were promoted by small quantities of special substances.

In the unavoidable absence of Dr. Paulo Carniero, who had hoped to be present, Dr. Frank Malina described the scope and purpose of the International Research Institute of the Hylean Amazon.

Sunday, September 12.

Apart from whole-day excursions the only fixture was an open evening meeting, in the Dome, at which Lord Samuel delivered an Address on Science and Philosophy (see page 287) before an audience of 750, who were undeterred by the severe storm which was sweeping the coast and many of whom arrived, still wet, and in some cases unfed, after a full day in the Weald. The theme of the Address was the reconciliation of science, religion and philosophy between which a sharp division had grown up since the Renaissance. Lord Samuel said that the leaders of thought must not for ever offer to the people contradictory ideas on fundamental issues: they should come together out of their professional compartments and across national frontiers to give the world the guidance it so urgently needed. The troubles of the world had come from science having advanced faster than morals, and the remedy was not to retard the progress of science, but to accelerate the development of moral standards. There were aspects of the cosmos which only religion could envisage. There was conflict between religion and materialism, but religion should not be identified with dogmas of ancient theologies which were contrary to the order of nature. Between science as such and religion as such there need be no conflict. Lord Samuel thought that philosophy might be the reconciler. On its empirical side it was linked with science; on its transcendental side it was linked with religion; so that it might serve to promote that synthesis of the three which was essential if the age was to be redeemed from past calamities and rescued from present dangers.

No official church service on Sunday morning was included in the local arrangements and, under

the stimulus of a misleading article in a national daily newspaper, this gave rise to a little acrimonious and futile discussion about the apathy of scientists to religion. A full list of the services arranged in all churches in Brighton was posted on the general notice board in the Reception Room as soon as the information was available.

Monday, September 13.

The Sections resumed their sessions and the remaining three Presidential Addresses were delivered during the morning. Prof. John Read read his Address on 'Specialisation and culture in Chemistry.' Prof. A. E. Trueman spoke on 'Geology today and tomorrow' and Prof. H. Hartridge addressed the Physiology Section on 'Recent advances in colour vision.' Prof. Trueman's Address was followed by a discussion on the training of the geologist and Prof. Hartridge's Address by a discussion on colour vision which was continued in the afternoon. After the Address by Prof. Read the Chemistry Section discussed Conservation of the Chemical Elements. The Physics Section received papers on magnetism in one of which, by Mr. D. A. Oliver, was given the first public description of an important new permanent magnetic alloy containing the rare element niobium. The Zoology Section considered some scientific aspects of British Marine Fisheries in the morning and some problems of colour perception in the afternoon. The Geography Section discussed movements of population in the Commonwealth with the Section of Anthropology who also received individual papers in the morning and discussed, in the afternoon, rural house types in Western European countries. The Psychology Section had a full programme of individual papers; the Botany Section discussed the genetical structure of plant populations in the morning and coppice management in the afternoon. Dr. George Taylor gave a popular lecture on Plant hunting in Tibet which was illustrated by exquisite colour photographs. In the Education Section the subject of discussion was the worker in industry and the Section of Agriculture considered control of environment in horticulture.

On the afternoon of Monday the Delegates from Corresponding Societies were entertained at a Conversazione in the Corporation Art Gallery. Sir Henry Tizard, with Presidents of Sections and the General Officers, took sherry with overseas guests of whom there were 12 from 6 countries. The President also met student exhibitioners of whom 90 from Universities and Colleges attended the meeting by special arrangement.

In the evening Prof. J. D. Bernal delivered the second discourse, on 'Waves and Beaches,' illustrated by films, lantern slides, blackboard diagrams and a rich fund of ancedote and topical references, all of which enthralled a large and grateful audience. Earlier in the evening Prof. S. J. Davies and Mr. F. G. Watts gave an open lecture on fuel and power economy with special reference to heat pumps.

Tuesday, September 14.

Electronic devices in industry was the main theme of the final session of the Physics Section and in this connection members of the Scientific Instrument Manufacturers' Association staged exhibits which were on view in the Corn Exchange on Monday and Tuesday. In opening this exhibition Sir Lawrence Bragg complimented the exhibitors on the standard of the display which was very high, considering that the industry was at that time pre-occupied with a large exhibition of instruments associated with a British trade fair in Copenhagen. The Chemistry Section discussed building materials with special reference to new materials; geologists and geographers met together to discuss denudation of the Weald; zoologists and botanists received and discussed a preliminary report on biology in the educational curriculum, and the two Sections met separately in the afternoon, the Zoology Section for a popular lecture by Mr. Peter Scott on wildfowl and the Botany Section for demonstration of exhibits; the Section of Economics held a symposium on economic aspects of food; the Sections of Physiology and Agriculture discussed the physiology of milk secretion; the Psychology Section considered the nature of incentives and the Education Section reviewed some problems affecting the selection of candidates for University education.

In the evening the Brighton and Hove Natural History Society and the Brighton and Hove Archæological Society entertained 200 members of the Association at a Conversazione in the Royal Pavilion.

Wednesday, September 15.

Section C (Geology) was the only Section with a scientific programme on the final morning, which was otherwise occupied with administrative and formal business. The General Committee met at noon and at the conclusion of the meeting passed the following resolution:

'At the close of the 1948 meeting the General Committee desire to place on record their appreciation of the invaluable local assistance which has greatly contributed to the success of the meeting and to express their thanks to the Mayor and Corporation for hospitality, to members of their staffs for many individual attentions and to those who helped in various ways to make a success of excursions and visits. Finally, the General Committee desire to express their sincere appreciation of the work of local secretaries of sections, and of the staffs of the Royal Pavilion Estate, Technical College, Training College, College of Art, and Brighton College for the way in which, by preparation and improvisation, they met the exacting and unusual requirements of the Association.'

SCIENCE AND PHILOSOPHY[1]

By

THE RT. HON. VISCOUNT SAMUEL, G.C.B., G.B.E., D.C.L.

1

To use a term familiar at Congresses of a different kind, I appear here to-night as a 'Fraternal Delegate,' bringing the greetings of the Royal Institute of Philosophy. I hope you will agree that it is desirable that scientists and philosophers should know one another better; should try to understand each other's language, and not carry on conversation, if at all, through some neutral interpreter. No doubt the unceasing elaboration of human knowledge, reaching out so quickly in every direction, compels us to specialise. But that brings dangers and needs watching.

I remember that, in my Oxford days, someone had invented a story that, in a neighbouring College, an undergraduates' Society had been formed with the title, 'Society for Viewing Things as a Whole.' Perhaps we ought all to regard ourselves as though we were members of some such Society. In particular, we can see plainly enough how much mischief has been done by the too sharp division that has grown up, since the Renaissance, between three of the chief activities of the human mind—religion, philosophy and science. They have gone their several ways, paying too little attention to each other's doings, glossing over contradictions between their conclusions, or even accepting such contradictions as natural and proper. But man's intellect is a whole; and if its various faculties say contrary things it must become confused, uncertain of itself, demoralised, ineffective. Perhaps we may see here one of the causes of the troubles and disasters that afflict our harassed times.

Philosophers, it must be admitted, find little credit in the world of to-day. Few listen to them. Such audiences as they once had have mostly gone off to listen to the scientists. There they will find something new and significant, self-consistent and convincing. For this, philosophy has largely itself to blame. It had offered to the world little else than conjecture and assertion based upon assumptions: made impressive, no doubt, by logic, and sometimes attractive by rhetoric, but not substantiated by knowledge and experience. Each philosophic system in turn was superseded by the next; and the whole process was becoming more and more remote from actuality, until at last Michelet expressed a conclusion that most ordinary people had reached, when he said, 'Metaphysics is the art of bewildering oneself methodically.' All this rested at bottom on the arrogant assumption, accepted from Protagoras, that 'Man is the measure of all things.' For this the universe gives no warrant. As a present-day satirist has said,

> The supercilious silliness
> of this poor wingless bird
> is cosmically comical
> and stellarly absurd.

2

Such was philosophy without science. And such, to no small extent, it still is; although it is more than three centuries since Francis Bacon proclaimed the obvious truth that if mankind wished to understand the universe and its processes they should at least take the trouble to examine it.

But many did listen. They forsook metaphysics, and, with energy and enthusiasm, embraced science. Beginning with physics and chemistry, they rapidly achieved successes that were amazing. So striking, indeed, that some among the scientists, and more among the laymen, jumped to the conclusion that the methods they had adopted—observation and experiment, mathematical calculation, induction and deduction—could be applied to all our problems, and might be expected in time to solve them all. Although many of the leaders—in this country T. H. Huxley prominent among them—disclaimed any such belief, the world at large inclined to the view that natural science had found in materialism the ruling principle of the cosmos.

From this came an emphasis upon things as against ideas. The production and consumption of goods ranked as the matter of chief importance. It is true that civilisation requires as its basis the maintenance and comfort of the whole population; but this was taken to imply that civilisation consisted

[1] Address delivered to the British Association on Sept. 12, 1948, at the Annual Meeting in Brighton.

mainly in that. Past history and present politics were to be interpreted first of all in terms of economics. Further, science had discovered that man was not the child of a special creation, but had been slowly evolved out of the body of nature ; also that nature itself was subject to the working of inexorable laws. This was thought to involve that all things, including man's own destiny, were determined by the blind working of autonomous forces. So religion became a fantasy, and freewill an illusion.

> The curtain's lifted
> The stage is set,
> Bow to the audience
> Marionette.

From this intellectual trend have followed, during the last hundred years, grave consequences. The age has been passing through a mood of pessimism. Man has felt himself lonely and friendless in a hostile universe. Pseudo-philosophers appeared, who were ready to drop the reins of reason and surrender control to instinct, intuition, superstition, or some fictional agency they miscalled ' History.' They won crowds of adherents and wielded vast influence. The old cynical view that politics is nothing more than a struggle for wealth and power between individuals, classes and nations, which had begun to yield ground before the advance of rational democracy, gained a fresh hold. In such an intellectual climate it was easy, in countries politically immature, for the followers of shallow but specious ideologies to seize power and establish the tyranny of a dictator, a group or a class.

Mark how this negative mood has affected the arts—particularly fiction, the theatre and the cinema. Not, of course, universally, but very widely, they have become frankly nonmoral. Crime is entertainment, murder a parlour-game, adultery taken as a matter of course ; compunction and remorse have little place, and religion never enters.

When we try to trace this mood of our time to its causes, we cannot fail to find among them these discoveries of science, and the hasty deduction that materialism logically follows. Here is an example of science misused by philosophy—as wrong as philosophy without science, and perhaps more harmful.

This has become widely recognised. Nowadays, outside Russia, few thinkers, scientific or other, would declare themselves materialists. Obvious facts, around us and within our own natures, point to a different conclusion. Life and mind, the emotions, the virtues and the vices, our consciousness of the universe, these are realities as authentic as atoms and molecules, radiation and gravity. They cannot be thought of in terms of chemical formulæ or mathematical equations, any more than—as the scholastics of the Middle Ages supposed—in terms of logical syllogisms or metaphysical categories.

3

This supposed conflict between things and ideas, materialism and idealism, which appeared to be a conflict between science and philosophy, was a false issue. We may see it as an outcome of what has been called, ' the philosophic craving for unity ' ; that obsession of human thought which seeks to reduce each problem to a simple choice between two specified alternatives. Is mind, as the evolutionists seemed to say, nothing more than an accidental product of matter, which alone is real ? No, said the philosophers. Then the alternative must follow, they went on, that matter is nothing more than a concept of mind ; it is that which alone is real.

But why should we for ever submit to a challenge ' will you have A. or B.', when often the right answer is, ' both A. and B.' ; or else ' sometimes A. and sometimes B.' ; or very frequently, ' neither A. nor B., but C. or D., or perhaps a combination of X., Y. and Z.' ? I often feel some impatience when I am asked whether I am a Platonist or an Aristotelian ; an optimist or a pessimist ; for collectivism or individualism ; a follower of Karl Marx or of Jean-Paul Sartre. It is like being asked which we prefer listening to, crooning or jazz. Often indeed the dichotomy is real and the answer must be definite. When A. is truth and B. is evident falsehood, or when A. is freedom and B. is tyranny, the issue is simple, the answer clear and the duty plain. But the cases are very many when we should refuse to accept the crude challenge ; when the answer to the dilemma should be Both, or else Neither. It may be so in this fundamental problem of mind and matter.

We have a test case close at hand within ourselves—the connection between brain and mind. We know more or less what we mean by those words, and we can bring them together with a hyphen and speak of ' the brain-mind relation.' But how that relationship is effected, what it is that the hyphen implies, we have no idea. That Sir Charles Sherrington is our greatest physiologist all would agree ; it is he who has pushed research in that particular province further than any man ; but Sherrington has felt obliged to say, ' We have to regard the relation of mind to brain as still not merely unsolved, but still devoid of a basis for its very beginning.' And lately, in a foreword to a reprint of his classical work on the Nervous System, he ends by saying, ' That our

being should consist of *two* fundamental elements offers I suppose no greater inherent improbability than that it should rest on one only.' Until further knowledge gives ground for some different conclusion, we may be well advised to admit such a duality.

4

Another instance of the confusion brought by the A. or B. dilemma is to be seen in the perennial controversy on freewill and determinism. Here again philosophy and science are supposed to have taken different sides.

Science had proclaimed unanimously—at all events until recently—that the law of causation is universal. Every event is the consequence of a combination of earlier events ; if exactly the same combination is repeated it will always produce the same result ; we say that the earlier stand to the later as cause to effect.

This causality applies, not only in the material sphere, but also in the sphere of life and mind. A farmer, when he breeds cattle or when he sows a field of corn, a gardener when he sets bulbs, manures his plants or prunes them, sees causation at work in the sphere of life ; he finds that the same combination of causes will produce the same effect ; if the result is different it is because one or more of the antecedents have been different. And we see all around us causation at work in the sphere of mind. Every lesson in a school, every sermon in a church, every speech at a meeting, assumes that thought and action are open to influence : in other words that causation applies in the sphere of mind. Nevertheless commonsense declares, and plain fact forbids us to believe otherwise, that individual human beings have a power of choice; can reflect, and—within the limits set by circumstance—they can decide, say or do what they will ; they are therefore morally accountable, to themselves and to their neighbours, for their actions ; in a word, they have freewill. It seems then, that here is a contradiction. Many have held that it can only be resolved if we imagine some miraculous exception to the law of causation, some loophole through which, by special favour, the human will, and that alone, can escape into liberty.

But we shall need no such desperate expedient if we recognise—what should, indeed, be obvious—that the causes that have made us what we are, have given us our character and lead us to act as we do, are not all of one kind, but are of two kinds—some are external to ourselves and some are internal. From without come our physical and mental heritage from ancestors and parents, our social environment, economic circumstances. From within is developed our Self, which is individual and unique ; with its perception, memory, intellect, power of choice, its will ; built up by its own past decisions and present habits. Both sets of causes are for ever at work, interacting, sometimes conflicting. Consider only the external factors, and you will say that our lives are determined by necessity ; we are puppets in the hands of destiny, helpless victims of circumstance. Consider only the internal factors, and you may say that man is like a god, without limit to his capacities. Take both together and you will reach the conclusion that the individual man, as he is at the moment, possesses a freedom that is real, carrying a responsibility that is unescapable. Able, in some degree, even to confront and modify the physical conditions of the globe he inhabits, his power is absolute over the organisations and agencies he has himself created—societies and nations, Parliaments and Churches, arts and sciences, cities and industries. Science will be satisfied when we have realised that the individual will is not outside the cosmic complex of causality, but within it—itself the product of causes, external and internal. Philosophy and religion will be satisfied when we see that—within the limits set by bodily nature and the earth's environment—the unique individual will, once established and mature, separated, so to speak, from the matrix of circumstance as the child from the womb, is truly independent and free.

5

I said just now that 'until recently' science had always taught that the law of causation applied universally. I had in mind the Principle of Uncertainty (sometimes called the Principle of Indeterminacy) that was propounded by Heisenberg some twenty years ago, and accepted by many physicists. Certain philosophic deductions were drawn from it.

After the revolutionary discovery of the structure of the atom by J. J. Thomson and Rutherford, physicists everywhere eagerly explored its consequences. It was found impossible to push to a conclusion the researches into the motion of the electron. Its velocity could be theoretically ascertained, or alternatively its position at a given instant, but not both. And this inability could never be overcome, because the method of investigation which had to be employed itself modified the phenomenon that was being investigated. Consequently the scientist can never obtain the knowledge necessary to predict the motion of the electron. The deduction that was drawn was that there is no proof, or possibility of

proof, that in the microcosmic world the law of causation reigns, and not pure hazard. If, it was said, there appears to be law it is only because our investigations necessarily deal, not with single units, but with aggregates of vast numbers ; the results that we can handle are not factual but statistical, not certainties, but probabilities based on averages.

From this, Sir Arthur Eddington, who was the leading exponent of the hypothesis in this country, drew the most astonishing conclusions. ' I must make it clear,' he said, ' that the scientific doctrine of indeterminism is not that there exist occasional exceptions to deterministic law, but that every phenomenon is to a greater or less extent indeterminate.' He went on to say ,' If the atom had indeterminacy, surely the human mind will have an equal indeterminacy ; for we can scarcely accept a theory which makes out the mind to be more mechanistic than the atom.' His conclusion was that ' Determinism has faded out of theoretical physics : . . . thereby science withdraws its moral opposition to freewill.'

If all this gave a shock to scientists, it came as an even greater shock to philosophers. The theory was widely discussed. It was made one of the main topics for consideration at the Ninth International Congress of Philosophy, held at Paris in 1937. While not questioning the facts presented by physicists, the opinions expressed there were overwhelmingly against the deductions they had drawn. It was pointed out that the case rested mainly on an ambiguous use of the word ' determine.' In the premises of the argument it was used as meaning ascertained or defined ; in the conclusion, in the sense of caused or necessitated. Because the scientist in his laboratory or at his desk cannot ' determine ' the movement of the electron, it does not follow that, in the other sense of the word, it is not ' determined ' physically by nature. Bertrand Russell has put the matter very clearly ; ' In one sense of the word,' he says, ' a quantity is determined when it is measured, in the other sense an event is determined when it is caused. The Principle of Indeterminancy has to do with measurement, not with causation.'

The philosophers also urged that it is wrong to say that we may not assume the existence of anything that is not observable. That is so, no doubt, when it is a question of scientific proof. But apart from such proof, there can be inferences that reason may legitimately accept. Where, as in this case, centuries of investigation into matters that are within our knowledge have shown that events are always the effect of causes, identical causes producing identical effects, with never an exception, it is legitimate to infer that, in matters beyond the range of our knowledge, the same law holds, unless there is reason to believe the contrary. In this instance such reason is not offered ; and cannot be from the nature of the case.

Nor was it only the philosophers who took this view. It was shared by three of the most eminent of our physicists—Einstein, Max Planck and Rutherford. Einstein has said, ' Indeterminism is quite an illogical concept. . . . When you mention people who speak of such a thing as freewill in nature it is difficult for me to find a suitable reply. The idea is of course preposterous.' And when it is said that a Principle of Uncertainty is the necessary consequence of Quantum Theory, we may be reminded that Planck, the originator of that theory, has written that, in his opinion, physical science must still be ' based on the strict and universal validity of the principle of causality ' ; and he said, ' I firmly believe, in company with most physicists, that the quantum hypothesis will eventually find its exact expression in certain equations which will be a more exact formulation of the law of causality.'

It is strange, in the light of these facts and opinions, that some leading exponents of science still speak as though Heisenberg's Principle of Uncertainty, and the conclusions drawn from it, had been generally accepted and were to be regarded as established ; they are prepared to rest upon this exiguous foundation so weighty a structure as the freedom of the human will. We can find for it a basis much broader and far less precarious.

6

I will offer one other present example of divergent trends in science and in philosophy.

The nineteenth-century conception of a material ether having, whether rightly or wrongly, been generally discarded by physicists, Einstein's Spacetime Continuum has been accepted as the medium that transmits radiation. But meantime a denial of the factual existence of space and time appears to have become more general among philosophers. Commonsense, indeed, cannot do without the notions of space and time. We are disposed to regard space as a kind of very large empty box, with the top and bottom and sides removed, and time as an ' ever-rolling stream ' ; but what such expressions may mean we have no idea. It seems better to regard the words space and time as our names for relationships between objects or events in a universe that is extended and enduring. Essential as they are, for mathematics as well as for practical life, they are

nevertheless figments. Like numbers, or the Euclidean point with no dimensions, line with one dimension, and plane surface with two, they are necessary as tools of the mind ; but they are not physical elements in the universe. Carlyle's poetic insight let him see this. 'The Where and When,' he said in *Sartor Resartus*, 'so mysteriously inseparable from all our thoughts, are but superficial terrestrial adhesions to our thought. . . . Think well, thou too wilt find that Space is but a mode for our human Sense, so likewise Time ; there *is* no Space and no Time.'

If that is so, then clearly a Spacetime Continuum that comprises them is a mental concept and nothing more. As such, no physical qualities or objective functions can be assigned to it. The two matters belong to separate orders. It is as though one should say that the number Eight was heavier than the number Four ; or treat the census as real rather than the people.

The incisive mind of Whitehead cut straight to the essence of the matter. 'There can be no true physical science,' he wrote, 'which looks first to mathematics for the provision of a conceptual model. Such a procedure is to repeat the errors of the logicians of the middle ages.' Again he speaks of confining thought to purely formal relations which then masquerade as reality. '. . . Science relapses into the study of differential equations. The concrete world has slipped through the meshes of the scientific net.' To confuse mathematics with reality would indeed be to establish a new scholasticism.

7

I have now offered four examples of divergences between scientists and philosophers—in the problems of mind and matter, freewill and necessity, causation and indeterminism, spacetime and reality. Clearly the conclusion is that efforts should be made to reconcile such divergences. The leaders of thought must not for ever offer to the peoples contradictory ideas on fundamental issues. They should come together, out of their professional compartments and across national frontiers, to give to the world the guidance it so urgently needs.

For, in the long run, it is ideas that rule. Not things ; nor yet force. Things are valued according to human choice. Force may be used or not used, for this purpose or that, to protect freedom or assail it, to maintain justice or overthrow it, according to the ideas that men hold on freedom and justice, force or persuasion. The two great wars that have desolated men's lives and devastated the world have been as much conflicts of ideas as were the wars of earlier centuries between religions. And the present tension, as we all know, comes from a conflict of ideologies. The leaders of thought should not leave the world's affairs to 'hissing factionists with ardent eyes,' as Wordsworth called them. Only when they themselves point the way can the intellect come out of the fogs and bogs in which it has been lost and wandering for centuries, to clear air and firm ground, where the urgent mind of man may press on to fresh exploration and new discovery.

Is there any hope of such an interchange of ideas, or of any good result coming from it ?

I have lately been attending the Tenth International Congress of Philosophy, held at Amsterdam. Comparing my impressions with those of the previous Congress eleven years before, I noticed a greater tendency to the practical. The Congress of Paris had been devoted to two subjects—the philosophy of Descartes, and what was then the new issue of Indeterminism. This one had as its central theme, 'Man, Mankind, Humanity.' Some of the seven hundred professors and students who came to it, from over twenty countries, took part in sections on Metaphysics, Mathematics, Logic, Language and the like. But the predominant subjects were Humanism, Ethics, Man and Religion, the Philosophy of History, Sociology. The Director-General and other representatives of Unesco (the United Nations Educational, Scientific and Cultural Organisation) attended, and some of their special problems were discussed at a series of meetings. At the closing session, the President of the Congress, summarising its proceedings, said that 'it had reflected the tendency of philosophy at the present time towards empiricism, and taking a part in the many activities of human life.' Philosophy indeed is tending to be less centred upon the problem of perception and knowledge ; also to be less historical and critical and more positive and constructive ; 'keeping an eye on the object'—the object being the cosmos of which we are a part, man's place in it and his own nature.

All this is of good augury for a closer cooperation between philosophers and scientists. If, pooling their ideas, they discover that differences have been caused by using the same words in different senses ; or that one has been arguing from assumptions which the other can show to be mistaken ; or that a discussion has proved abortive because limited to alternatives narrower than they need have been, then contradictions may be resolved. In so far as we can reach truth, sooner or later they must be, for no one truth can contradict another truth.

8

To refer again to Albert Einstein—I well remember, when I had the privilege, about twenty-five years ago, of being his host at Government House in Jerusalem, and was walking with him one day along the ridge of the Mount of Olives talking of many things, his saying that he thought the present troubles of the world had come through science having advanced faster than morals ; only when morals caught up with science would those troubles be ended.

Most people, I believe, would agree with that. But some seem inclined to draw the conclusion that the fault has been with the advance of science ; that it has been too fast ; or even that it has been a mistake altogether.

They say that it was science that made possible the inventions of the engineer and the discoveries of the chemist which produced the Industrial Revolution. The characteristic features of our present-day civilisation have come from that—crowded industrial cities, with their hurry and strain, their ugliness and dirt ; mass-production of things in place of craftsmanship, of human types, rather than individuals. To science also we owe the rise of materialism and the decline of religion, with world wars as the outcome and atom bombs the climax. It would have been better, they say, far better if we had never left the simple ways and abandoned the simple faith of our forefathers.

An age is prone to depreciate itself and to idealise the past. Were there no wars before the advent of science ? Constant and cruel were the wars between dynasties, nations, races ; and between religions—Catholics and Protestants, Churchmen and Independents, Christians and Moslems, Moslems and Hindus ; with persecutions, massacres, assassinations beyond counting. In those times thought was repressed and knowledge scanty. Serfdom or slavery was the lot of great multitudes ; the common people everywhere, mostly illiterate, were born to lives of brute toil. Vagabondage, highway robbery, crimes of every kind, were rife. Epidemics killed millions ; a quarter—a third of the children died ; adult life was often short ; old age, if attained, racked with infirmities. Two things have rescued us, not indeed from all, but from most of this : one, democracy ; the other, science.

Did science do us injury in preventing disease, softening pain, lengthening life, easing death ? In lightening the labour of millions by creating the slaves of the modern age—the machines ; a hundred times as strong and a hundred times as long-lived as the human slaves of the ancient world ; working hard, fast and unresting without cruelty or hardship ? Was there injury in making our fields more fertile ; giving us new materials ; creating an abundance that enriches human lives through comfort, greater leisure and the amenities that art and invention can bring ? Nuclear energy itself—if turned to peaceful uses—opens prospects of a material ease beyond even the imagination of our ancestors ; and if that is not yet within our grasp, it is certainly within the range of reasonable hopes. Has science hurt us by enlarging knowledge, disseminating it through the printing-press, and now—most wonderful of all the mechanical inventions—the radio ? The credits of scientific achievement, even at this hour, far outweigh the debits ; and if we view things, not only as they are, but as in process of becoming, the balance may prove more favourable still.

That these vast new powers and opportunities should often have been turned to mischief is not the fault of those who have bestowed, but those who have misused them. Not science is to be blamed ; but the treason of some among the thinkers, the weakness, the blunders or the crimes of statesmen, the passion of peoples. The scientist as a citizen shares in the responsibility that belongs to us all ; no special or final responsibility is imposed by his calling. He deals with means ; it is not for him to set the ends of human action. That belongs to ethics ; and ethics can find guidance only in philosophy and religion. Not science is shaken by the shock of the atom bomb ; it is philosophy and religion, because of their failure to give to modern man an effective moral leadership.

'The troubles of the world have come from science having advanced faster than morals'—yes, but the remedy is not to hold up science ; it is to speed up morals. Here we must invoke religion ; there are aspects of the cosmos which it alone can envisage.

Religion and science, it has been thought, cannot go together. There have been, and no doubt there still are conflicts between some of the tenets of the ancient theologies and facts that research and discovery have established. And there is plainly a conflict between any form of religion, as commonly understood, and materialism. But science is not to be identified with materialism, nor religion with dogmas contrary to the order of nature. Between science as such and religion as such there need be no conflict.

Philosopher may be the reconciler. On its empirical side it links with science ; on its transcendental side it can join hands with religion ; and it may serve to promote that synthesis of the three which is essential if the age is to be redeemed from its past calamities and rescued from its present dangers.

So far from conflicting with religion, science will strengthen it. Our latter-day knowledge, unveiling a universe around us and within us that was always there but hitherto unseen and unknown, has revealed an organic whole harmonious and majestic beyond the conception of earlier ages. And this is not the speculation of a wistful hope ; nor some apocalyptic vision ; nor the vague inklings of hypnotic trance. This is waking fact. This is a reality any man can perceive, here and now ; brought within range of his perception and understanding, by the help of appliances of exquisite ingenuity, through the laborious constructions of painstaking thought — up from the depths of the atom, down from the height of the stars.

What a theme here for a poet ! And what a text for the preacher ! For this is not to undermine religion. By helping to simplify, purify and enlarge our conceptions of the cosmos and of Deity, science may join in offering to modern man a faith that can satisfy his emotions and justify his innermost beliefs, without offending and alienating his intellect. This is not to destroy, this is to exalt religion.

You, the members of this great Association, will go forward with your work for the advancement of science, sure of its worth, confident in its future.

THE INFLUENCE OF FORESTRY ON THE COMMUNITY[1]

BY

W. L. TAYLOR, C.B.E.

AND OTHERS

If the evolution of plant life on this planet had failed to produce trees and nature's laws concerning succession of species had stopped short of creating forests, how vitally might developments of human culture have been retarded and altered. From the age of our wild, and possibly woolly, ancestors to the present day, the forest and its products have contributed generously to the comfort of mankind. We are bound to acknowledge the tremendous civilizing influences of trees and their timbers which, in form and substance, have inspired succeeding generations to discovery and invention. In retrospect it is easy to realize how much less bearable human life would have been through the centuries without forests and their derivatives, while we have only to cast our eyes around us to see how dependent we still are on the primary produce of the forest.

The influence of forestry on the community is material or economic, physical and psychological, and is exercised through the living organism of the forest itself and through its products. In the Dark Ages and after, we may assume that the great trackless forest was a thing of mystery and often of dread. It was the home of beasts of prey, of eerie noises, and of strange lights and shades, giving rise to primitive fears and fancies, some traces of which continue to survive, especially in countries in which forests have place as part of the everyday life of the countryside. None can deny that forests and trees have given powerful stimulus to thought, to the arts, and to fine craftsmanship. In far-off days, the forest furnished shelter, food, and materials for tools and weapons. Who is there to doubt that the tree, or its members, did not yield the prototypes of many things we commonly use ? But there is a reverse side of the picture because wherever the human species has encountered natural forest a process of destruction has begun, and unrestrained forest destruction without the compensating influence of forestry has always reacted to the disadvantage of mankind and always will so react. The tendency of rising populations to clear forested land for agriculture as well as to obtain timber has been universal. Carried to excess it has brought loss and distress to many lands, even in modern times. In our own island, anciently an extensively forested country, the process of forest denudation commenced centuries before the Roman occupation and has gone on

[1] The text of Mr. W. L. Taylor's address as Chairman of the Sub-section of Forestry, followed by contributions to a discussion on the subject of the address. Brighton, September 10, 1948.

progressively ever since, always without effort to conserve or reafforest that can rightly be called sustained effort. No primeval forests are now left to us in Great Britain. A few small areas of natural pine and birch survive in the Highlands, and elsewhere perhaps some other silvicultural curiosities such as Wistman's Wood in Devon, but, for the rest, our woods are artificial in origin, for which we owe a debt to the art of forestry.

Only some 5 per cent. of the land area of Great Britain is now classed as woodland, a percentage that compares badly even with small and densely populated Belgium, where the area under forest amounts to 18·4 per cent. A great deal of our reputed woodland has ceased to bear an economic forest crop. The actual extent of the properly stocked woods that remain after the ruthless fellings of two wars will not be known until the Census of Woods now in progress is complete, but it is much less than 5 per cent. of our acreage. The old British woods extend from an acre or so in area to over a thousand acres, but few of them can be dignified by the term forest. Up to the end of the first World War, systematic forestry was practised only locally on a few estates and in the Crown woods. This, and the fact that, following the repeal of Forest Law as exercised by Saxon and, more intensively, by Norman kings, so many woods have been closed as game coverts and private demesnes, have effectively obscured to most of us the place that forests and forestry should take in the economics of the countryside and of the nation, and has destroyed that forest sense that is so marked a quality among the town and country folk of most of the Continental countries and which the United States are now working hard to inculcate. The concentration of the larger part of our population in the towns, dating from about the end of the eighteenth century, has been no help. We are bound to admit that as a nation we have little to boast about in our history as foresters.

We need to realize that forestry is a branch of husbandry and that trees are a crop equally with any cereal. The work of the Forestry Commission and the private owners who manage their woods systematically will, in time, bring back into proper perspective all that forests mean to the nation, but there is much missionary and practical work to be done before we again become forest minded as a people. Wood as a raw material has been taken for granted. It was easily bought abroad and imported, and the relatively small contribution to supply made by the home timber trade was of little account although, without it, we might well have failed to maintain the nucleus of trained sawyers and operatives whose skill has enabled us steeply to step up war-time production. Nowadays, timber is less plentifully obtainable from any source and much dearer to buy, while the excessive fellings from our already meagre reserves in course of the present century have reduced our resources of growing timber to proportions for which contemptible is not too strong a word.

To us in this island kingdom wood is of especial economic importance. As events have shown, we cannot in all circumstances rely upon seaborne supply. For this the only remedy to promise security is to raise up a series of managed forests in Great Britain sufficient to maintain supply in time of need and at the same time to relieve the import position. The necessary area of forest to give this safeguard has been put at 5 million acres, made up of 2 million acres of replantings and 3 million acres of afforestation. Fifty years is the period fixed within which to carry out the task which, when completed, will secure some two-fifths of our normal yearly consumption, and provide a reserve against any emergency in which overseas' supply may fail us. The bulk of our planting must be of coniferous trees because softwoods are 94 per cent. of what is required. When once established on the principle of sustained yield, forests yield crops that are perpetually renewable and a yield that is perpetually maintained.

There is no lack of suitable land nor is it really necessary to encroach more than lightly upon potential food production for our new forests. Man does not live by bread alone, and it is not the land capable of arable cultivation that is required. Given better management of the upland farms, and in this there is admittedly room for great improvement, our hill grazings can be made to support a greater head of stock than hitherto. Seventy years ago, we grazed 30 million sheep. Now the flocks are down to a little more than half this number, but the land is still there and what has been done in the past can be done again. Growing populations impose the need to improve land use in this country as well as in other lands : advances in agricultural science point to ways and means. On a yearly basis the land of Britain is capable of producing more than we have yet drawn from it. The forester and the farmer are equally primary producers and, with understanding of each other's aims and methods, can live and work together in amity and mutual respect.

To many minds, forestry is dismissed vaguely as a long-term undertaking. The conception is that a man may plant but has little hope of living to harvest his ultimate crop. Forest policy is, and must be, planned

far ahead and to serve its purpose must be unremittingly pursued, but in regard to certain forms of forest cropping the long-term idea tends to be overdone and to obscure the true issues. For instance a crop of pitwood running from 50 to 70 or even 80 tons to the acre can be produced in Great Britain, with certain species and on appropriate sites, in the short space of 15 to 20 years, and similarly it is possible to grow softwood timber large enough for the saw-bench within 40 years, revenue from thinnings being obtainable in the meantime. The popular conception is, of course, true enough with most of the common hardwoods, and true in all cases where timbers of large dimensions are required, but the overshadowing influence of long deferred returns has frequently had adverse effects on the judgments of governments and individuals in regard to our forestry in the past.

In the circumstances in which we find ourselves there is a real urgency to build up a national reserve of growing timber of the kinds we need. An example that will be obvious is that of pitprop supply, without which the coal-mining industry would come to a stop. In spite of talk of steel, the day when the wooden prop will be superseded is not in sight and it is inconceivable that our basic colliery industry should be left entirely at the mercy of foreign supply. If coal should fail us all else would fail. It is to be remembered that the annual consumption of wood per head of population had risen from 3½ cubic feet in 1850 to nearly 11 cubic feet in 1910. At the moment we cannot obtain enough to cover our reasonable requirements, and if from time to time the progress of science does find substitutes for this most useful primary product, technical men are constantly discovering other uses. Like leather there is nothing just like wood.

The influence of properly sited forests goes far beyond the commodity value of their produce, great as it is. The drift of population from the land has long been a political problem and one that is still with us. The system of land use in force for the past two hundred or more years has failed to hold the former populations to the land in the more remote parts of the country. Amenities such as roads and electricity will fail to re-attract men and their families to these parts unless additional wage-providing industries are also established. The part forestry can play is obvious ; the great forest now growing up in the sparsely inhabited Border Country is a clear example of this aspect of afforestation, for already the day is foreseen when a thousand men will be employed in planting, tending, and extracting timber from the valleys of the upper North Tyne, Rede, and Liddle, on lands on which no more than a sparse shepherding population with a scattering of railwaymen have hitherto dwelt. Nor can enterprise of this sort operate to the disadvantage of farming in general because there are seasons for forestry work and for agriculture, and workers can be interchanged accordingly. Moreover, trees in the mass tend to alter local climates for the better by reason of their effects upon soil humidity and the large-scale shelter afforded. Is there really any doubt that assurance of a life's work at a living wage will not do more to repopulate the silent valleys and hills throughout the more distant country districts than any remedy for the townward drift yet conceived, and can the influence of forests in this regard fail to benefit the nation? I think not. And this is not the end because local wood-working industries will also spring up, based on the unfailing supply of raw material that systematic forestry provides, and still more locally housed workers will be needed.

Another problem to be faced by the people of Britain is that of water conservation. In this the service of forestry is acknowledged, not because trees attract more rainfall, as often supposed, but because forests, as containers and regulators of flow, tend to stay wasteful run-off. Soil erosion is yet another matter that gives rise to very serious consideration indeed in many parts of the world. For centuries China has suffered ; India and South Africa are more modern examples of loss ; and later still the ' dust bowl ' area of the United States, together with its causes, have given much stimulus to thought and action. This risk is not without its dangers in East Africa to-day. Destruction of covering vegetation, including forests, has resulted in untold woe to the human race, a great part of which could have been avoided by forest conservation and could still be mitigated by afforestation. Fortunately, in this country, erosion has not yet been the cause of national disaster, but losses of soil do occur and forests are a safeguard.

Here at home we do not yet realize all that we lose for want of forests and free access to woodland. Quietude and recreation are found beneath the trees. Six of our British State forests, old and new, are already open to the public as National Forest Parks. As soon as more of the newly planted forests are reasonably safe from fire, more of them will be made available for public enjoyment. The popularity of the first practical application of the National Park idea in Great Britain—the National Forest Park in Argyll, which lies within reach of the great city of Glasgow—was immediate and has been sustained in a most encouraging degree.

I have already alluded briefly to the bearing of forestry and forest lore on the mind and

on the arts. This influence takes many forms : For instance there is the world-wide influence of the printed word for which the common vehicle is paper. In great part paper is now made from pulped wood, and pulp of wood is primarily a product of forestry. Again the forest is the background of folklore and legend the world over. As to the arts, music, painting, sculpture and architecture all owe a tribute to the woods, which have also been the theme of much poetry and prose. Forests afford a promising field for biological study and help us to preserve our dwindling wild life. We may regret the species that have been persecuted to the point of extinction and marvel that others, now rare, have managed to survive the exigencies of game preservation and collectors' zeal without the shelter of forests, any extension of which cannot, by and large, fail to be of advantage to the cause of scientific study and of our natural history.

But by nature, if not in politics, we are a conservative people. Changes are often abhorrent, and this is especially so where changes and the reasons for change are not understood. Anything tending to vary land use that has become traditional or to change the face of the countryside is apt to be resented. This, in fact, is one reason why the blessed word ' amenity ' has been spoken so frequently of late years and we hear much about ' preservation ' as applied to the *status quo* of hill and dale. Complaint is based on a fundamental fallacy, of course, because, as we know, nature is never static. It so happens that the chief bone of contention, the conifer, produces the kinds of timber of which we stand in greatest need. In proper setting, and there are many in Great Britain, maturing conifer forest can be as pleasing to the eye as any other and will, I believe, so be judged. We are perhaps fortunate that economic circumstances do not compel us to plant forests of Lombardy poplar or that unique conifer the Araucaria.

To sum up, forests represent national wealth and health. To us they also represent security and an assurance of a surprisingly large number of the comforts to which we have long been accustomed. Forests are conservers of soil and water. Forestry offers a sound basis for trade and industry and a means of repopulating large areas from which our hitherto all too narrow rural economy has driven the former dwellers. Abundant raw material will always draw new industry. The turn-out from new forests will have repercussions on the national income, on employment, on craftsmanship, and on trade, that are certain to benefit us all in our struggle to maintain a satisfactory standard of living.

Forest products are essential in peace and war as all nations who neglect to practise forest thrift ultimately learn to their cost. Freedom of access to forests has educational, scientific and recreational possibilities in which alone lie the hope that an understanding of the forester's art may spread among our people. By exploitation and carelessness (especially in regard to forest fire) the accessible forests of the world are being consumed faster than they are being replaced, a state of affairs that is all too plainly to be seen in the Island of Great Britain. Forests gave us the beginnings of our national culture in no small degree ; our woodlands have been an inspiration, and a standby in bad times, but our history does not hold us blameless as trustees of our forest heritage. All that neglect of forestry has so nearly lost to us, the forester can restore.

After the delivery of the above address there was discussion to which the following contributions were made.

Prof. F. T. Brooks, C.B.E., F.R.S.

THE Chairman has spoken with the authoritative voice of one who has long been associated with the Forestry Commission and has been Director-General of forestry in Great Britain. His address has covered the many aspects of the influence of forestry on the community, and all that I can hope to do as a botanist and as a member of the public interested in woodlands and forests is to stress some of the considerations already placed before you.

It will be admitted by everyone that wood is one of the primary commodities required by man, whether in the form of timber, firewood, or as an essential raw material for newsprint, rayon, plastics, and many other things. Demand is continually expanding as population increases, and the point has already been reached when owing to ruthless and inconsiderate exploitation in the past certain valuable timbers are no longer available in commercial quantities. For example, since European settlement in New Zealand the Kauri pine, one of the most valuable soft woods, has been nearly exterminated. Nowadays civilised communities are alive to the dangers of excessive exploitation but public opinion cannot be too emphatic about the need for judicious management of natural forests. Only in parts of Amazonia, New Guinea, Indonesia and tropical Africa are there still large unexplored forests, and when the time comes for them to be exploited it is essential for the extraction of timber to be properly controlled. There is constant pressure on the natural forests of the world for replacement by cultivations of various kinds, partly owing to increases in population, and the time is soon coming, if it has not already

been reached, when a limit will have to be set to forest destruction if serious disaster is to be avoided. Within a period of fifty years, from about 1890 onwards, practically the whole of the high forest on the western side of Malaya has been replaced by rubber plantations.

Nor must it be forgotten that many other valuable products besides timber come from the forest. Before rubber plantations were established in the eastern tropics rubber came exclusively from the Amazonian and African forests. To this day many primitive peoples obtain their whole livelihood from forest areas.

In temperate regions with an adequate rainfall some soils are better suited to forestry than to agriculture. In our own country the Forestry Commission has largely utilised areas of this kind for its plantations. For example, the sandy wastes of Breckland have been replaced by a large coniferous forest, and many of the lower mountain slopes of the Border Country, Scotland and Wales are now developing as extensive forests, leaving the higher slopes for hill sheep grazing. Some fear has been expressed that the establishment of forests on elevated land may adversely affect hill sheep farming, but in reality these interests are not incompatible and judicious compromise can be reached. Altogether apart from the dire need for greater timber production in Great Britain the policy of the Forestry Commission is economically sound, and eventually there will be a bigger financial return than if these lands had been allowed to remain as hitherto. In addition afforestation has led to the retention in the countryside of a considerable labour force which would otherwise have drifted to the towns, a most commendable policy in this over-urbanised country. In many areas the Forestry Commission have established small agricultural or horticultural holdings for some of their forest workers on which they can work either in their spare time or when forest duties allow. Most of these small holdings have been very successful. As time goes on the settled labour force will be increased and when the forests begin to be exploited the country population will be further enhanced.

During the two world wars there was necessarily wholesale felling of mature woodlands in this country, hard-woods as well as soft-woods. Many of these areas are now derelict and covered with brambles and other noxious growths ; they are conspicuous eyesores to the community at large and a complete waste of the land. If skilled supervision, labour and adequate finances had been available these sites might have been replanted almost immediately after felling. As it is they constitute a most serious silvicultural and financial problem, but it is hoped that they will be eventually re-established as woodlands, if not by private landowners then by the Forestry Commission.

The Chairman has called attention to the importance of forests in the conservation of water supplies and the regulation of water-flow. I should like to give two instances of this from my own experience. During the early settlement of New Zealand the natural forests were destroyed in some parts of the country, even on the lower slopes of the hills, in order to provide for pastures. These forests regulated the flow of rain water to the rivers, but when removed gully erosion set in and disastrous floods occurred which did untold damage to the pastures and to settlements in the valleys. Gully erosion is always liable to occur whenever forest cover is removed, the valuable surface soil is washed away, and the land becomes derelict. This type of erosion has occurred in many countries where due attention has not been paid to forest conservation and management. The other illustration concerns the island of St. Helena. When the island was discovered it was covered with a rich forest vegetation. After settlement had begun goats were introduced which destroyed practically the whole of the indigenous vegetation. Gully erosion ensued and when I visited the island in 1929 St. Helena was obviously one of the most impoverished places on the earth.

Trees are also a great protection against soil erosion by wind. One of the principal measures taken in the United States ' dust-bowl ' to regain the land for cultivation and to prevent further erosion is to plant strips of trees at intervals across the prevailing wind ; this has led to a considerable measure of amelioration. In Scotland the Culbin Sands on the southern shores of the Moray Firth—a long stretch of formerly unfixed dunes—have been reclaimed for productivity by planting conifers on an extensive scale. These plantations have fixed the dunes and have protected the valuable agricultural land behind from being overwhelmed by sand. The trees have grown well and some of the earlier plantations have already been exploited. On a larger scale and in a similar way the Landes region of south-west France has been reclaimed by forestry and is now one of the most valuable parts of that country.

If forestry has certain duties towards the community the community has no less serious obligations towards forestry. In this connection I would like to emphasize the danger of forest fires. A burning cigarette end or match thrown away in the forest or near it or an unquenched picnic fire may be the means of utterly destroying thousands of trees which it has taken years and endless trouble to nurse.

We are not yet sufficiently conscious in this country of the danger of forest fires, particularly those of us who dwell in towns. Those who have seen the charred remains of a large forest will never forget the terrible sight. In 1939 untold damage was caused by bush fires in south-eastern Australia. Subsequently I had to pass through one of the burnt-out forests, which consisted of giant Eucalypts. For a stretch of thirty miles I passed through the blackened remains of the trees without seeing a vestige of green, the most dismal sight I have ever seen.

Apart from the need to ensure the continued production of timber as one of the prime requisites of human life and as a means of protection of certain aspects of crop production and other essential services, woodlands and forests make a poignant appeal to the aesthetic side of our nature. How poor the world would be if there were no forests ! Even the townsman stands in awe when first he visits the forest and sees the majesty of canopied tree growth. Similarly the botanist who has his first glimpse of the tropical rain forest, so much more luxuriant than anything to be seen in temperate climates ! With the ever-increasing mechanisation of the age let us all therefore do our utmost to preserve one of the greatest glories of Nature, its woodlands and forests.

To foresters, botanists and naturalists woodlands and forests have a special appeal for they constitute a varied series of experimental areas where the most entrancing investigations can be carried out. There are still unsolved silvicultural problems in this country which will intrigue foresters for many years to come. Much attention has been paid by ecologists in recent years to the study of woodland vegetation, but this field of investigation is inexhaustible. Not only can the phanerogamic botanist be catered for in these areas, but also the bryologist, the mycologist, the soil microbiologist, the ornithologist, the entomologist and other devotees of science. Although not technically a nature reserve, each woodland is a vast reservoir of scientific problems, capable of interesting students for generations to come. The trend of botany is more and more towards the study of plants in the field, and in this connection it may be interesting to state that Cambridge University has recently purchased a woodland of broad-leaved trees where students can undertake investigations of various kinds. Even conifer plantations, although usually of little interest to the flowering plant specialist, have their own natural history problems. In the recently established pine plantations in Breckland I have seen some of the most marvellous displays of fungi in the autumn I have ever witnessed.

The British public are duly grateful to the Forestry Commission for the establishment of a number of National Forest Parks in which it can roam unimpeded, and for the promise of the creation of more of them when serious danger of fire is past. It has already been pointed out that the National Forest Park in Argyllshire has been most successful. The Forestry Commission has also provided on some of its extensive areas ecological reserves where the natural vegetation and its changes with lapse of time can be studied by terms of University workers, and I am sure that botanists and naturalists generally are most grateful for this enlightened policy.

In conclusion, it is clear that we must become more forestry minded in this country. Great developments are proceeding under the aegis of the Forestry Commission, and it is necessary to create an enlightened public opinion to support its efforts and also those of private landowners who are trying to re-establish their woodlands. But the issue is really much wider than this, for unless world opinion is insistent that adequate forest reserves, properly managed, are maintained in all countries where trees flourish, grave disaster will follow. Let us all, therefore, become friends of the forest !

Mr. A. H. Gosling

Our Chairman has stated that the influence of forestry on the community is, on the one hand, material or economic and, on the other, physical and psychological, and is exercised through the living organism of the forest itself and through its products.

The material or economic influences are not difficult to appreciate if one knows the facts. There is, however, in this country still insufficient knowledge among the general public of what forestry does mean and that is one reason why it is fortunate that the subject was chosen for this session. The position is, I think, changing slowly for the better. During the early part of the Commission's life, it could only speak as it were prophetically. Now, after nearly thirty years, it can point to concrete examples. We are now beginning to do what we have before only been able to forecast as a development—build new villages and extend existing ones. Mr. Taylor has mentioned one example—the large-scale area around Kielder in Northumberland. This is one of many—and as these facts get known the material influences of forests will begin to be more readily and widely appreciated. But I myself always feel that the effect of this development is something more than merely providing houses and jobs for men who are unemployed or are persuaded to earn their living by working in our forests. It is a great

asset to a country to have a substantial part of its population engaged in the country as distinct from the towns. The effect of working in the country with living things—the contact and struggle with nature—is fundamentally beneficial to man, whether the individual is conscious of it or not. I have watched this influence at work on men brought up in sordid, industrial surroundings, who were forced by economic depressions, not inclination, to migrate to the country, and the results have in a number of cases, though admittedly not all, impressed me very much. Men develop an independence, a happier and sounder philosophy of life, and a steadiness (which is easily mistaken for slowness of thought), which has its influence not only on the local community but ultimately on the nation itself. The same may be said of men employed in agriculture, but perhaps I am biassed in thinking that the forest influence in this respect, possibly because of its long term outlook, is the greater.

There are probably two fears about forestry in this country which give rise to some misgiving—it would be perhaps more accurate to say are loudly expressed. One is the effect of large-scale conifer planting on amenity, and the other is the effect on food production of planting on grazing land. Both have been referred to by the Chairman. On the question of agriculture versus forestry, there was some discussion at last year's meeting of the Association in Dundee. On that occasion, I drew attention to writers who, 100 and 150 years ago, were saying just the same things that are being said to-day. There is ample scope for both agriculture and forestry if these great industries work together in a spirit of co-operation, and I do not believe the result will be anything but mutually and nationally beneficial. Real progress is being made in this co-operation and as the Ministers responsible for agriculture are also now responsible for forestry, there is every facility for co-ordination of effort and that co-ordination is being satisfactorily achieved. I believe this is a big step forward and as the results of this become more evident the misgivings will fade if not disappear. It is still true to-day, as it always was, that land should not be taken for forestry if it is worth while improving for agriculture but at the same time forestry cannot be relegated to types of ground which are so unproductive as to be of little value either to forestry or agriculture.

Our Chairman spoke of the ' blessed word amenity.' I think again that there ought to be no real conflict between forestry and amenity. One of the difficulties is that everyone has his own idea of what constitutes good amenity and so there is no agreed standard with which one can compare. Ideas change. To-day, controversy generally centres round the conifer. One might be tempted to say that in some extremists' view : ' Every prospect pleases, but only the conifer is vile.' In this thickly populated country, every highly cultivated prospect is to a great extent artificial in the sense that it is not in its natural state. The landscape of to-day owes a vast amount of its character to man. Bare hillsides—now sometimes so admired—were once clothed with trees and so on. Changes take place in the natural course, and when they take place rapidly enough to be noticed, they are seldom popular at the time. We do not blame our forbears for spoiling the amenities by planting. On the contrary, we admire their woods, be they conifer or hardwood—or such of them as remain—and if we criticise at all it is because they did not plant enough. Similarly, we in our time need not fear blame on grounds of amenity, but we certainly shall fail in our duty to succeeding generations if we do not plant on a large scale. There are two hard facts which need to be more widely appreciated. Firstly, we cannot afford, in this country to-day, to have lying unproductive land which is capable of growing a good crop of timber. Secondly, much of the land available is not suited to hardwoods and, during establishment at least, there is no choice but to use conifers. It is a fortunate coincidence that our need of soft woods is proportionately much greater than hardwoods. On the other hand, foresters should keep the question of amenity well to the forefront in planning their work. Much can be done to meet sound criticism by careful attention to such things as sighting of fence lines, leaving viewpoints open, introducing variety of species, and so on. This has not always been done as well as it might have been. I am convinced that if the problem of amenity is approached in the right spirit of co-operation by all concerned, it will always be found capable of solution.

SOME BIOLOGICAL ASPECTS OF COLONIAL DEVELOPMENT[1]

By Sir FRANK STOCKDALE, G.C.M.G., C.B.E.

I have been asked to introduce a series of papers and discussions which deal with certain issues concerning development in the Colonial Empire, but before doing so it might be desirable to give a brief account of Government policy in regard to Colonial Development.

All are aware of the considerable interest which is being taken by the people of Britain in this matter at the present time and of the importance which is attached to the further development of Colonial territories in the interests of their inhabitants, the Commonwealth and the world in general.

In some quarters extravagant views have been expressed both in regard to the extent to which deficiencies of certain foodstuffs and raw materials in Europe can be met from Colonial territories, and as to the speed at which this can be achieved. Such views display ignorance of Colonial affairs generally, a lack of knowledge concerning the feelings of the Colonial peoples, their own food requirements and their social customs and habits, as well as an adequate recognition of the poverty of many Colonial soils, the liability of many of them under certain conditions to erosion, the vagaries of the rainfall, the shortage of water supplies and the hazards which may be expected from pests and diseases.

Taking a long view, there are vast possibilities still awaiting development, and many of the Colonial peoples themselves are anxious to see the execution of projects which will further develop the natural resources and provide for them a wider field of occupation with improved standards of living. The road to achievement will, however, not be a short one and will only be traversed successfully if there is careful and sympathetic planning as well as persistent efforts to overcome the difficulties which will be met.

Government Policy in regard to Colonial Development

This policy is designed to improve and extend the public services, and to encourage economic developments as far as natural conditions and resources permit.

Twenty years ago there was no means whereby a Colonial territory could obtain financial assistance other than through a guaranteed loan to enable it to pursue an active policy of development. Its efforts, as also the expansion of services, were limited to the extent of its own resources. This position was modified by the passing of the Colonial Development Act of 1929, and progressively increasing state assistance has been afforded to Colonial territories by the Government of the United Kingdom through the Colonial Development and Welfare Acts of 1940 and 1945.

Under the last Act, which provided for financial help to the extent of £120 million spread over ten years, allocations have been made to Colonial territories for their post-war plans, and for centrally administered schemes to promote surveys, research, higher education and training.

The majority of the Colonial territories have now prepared Ten-Year Development and Welfare Plans, which have been accepted by their legislatures and approved by the Secretary of State for the Colonies.

These plans are flexible and will be financed by bringing in local financial resources—including loans raised by Colonial Governments either locally or in the United Kingdom—to an amount which will be double that provided as grants from the United Kingdom Exchequer, but, so far, even in the case of the most advanced of these plans there has been a great lag in execution. The shortage of administrative and technical staffs and the continued shortage of supplies of materials—particularly steel, cement and consumer goods such as textiles—have accounted for the delays, and until these shortages can be overcome, the execution of many of the works contemplated is bound to take time.

An overall analysis of these Colonial plans show that the amounts to be spent on economic development and on social services will be approximately equal.

The Government has further decided that special efforts must be made in the economic field if the natural resources of the Colonial territories are to be actively developed, higher standards of life assured and expanded services maintained.

In order to secure this expanded economic development, the Overseas Resources Development Act was passed by Parliament in the beginning of this year, and provision was

[1] Paper read to Section D at Brighton on September 10, 1948.

made for the establishment of the Colonial Development Corporation and the Overseas Food Corporation.

The latter with a capital limit of £55 million is charged with the execution of the East African Groundnut Scheme, which is to be described by Mr. Wakefield, and with other schemes for the commercial production of foodstuffs in short supply in the United Kingdom.

The Colonial Development Corporation with a capital limit of £110 million is designed to undertake projects calculated to aid Colonial development generally, and benefit materially the peoples of the Colonial territories by the fuller use of the natural resources. Its activities will cover agricultural schemes (for agriculture is basic to the general economy of practically all Colonial territories), forestry schemes, fishing developments, mining enterprises, as well as industrial, processing and manufacturing undertakings. The Corporation has to balance its income and expenditure, taking one year with another, and it may undertake projects on its own, in co-operation with Colonial Governments or in participation with private enterprise. The projects must be commercially sound, and it is the intention of the Corporation to supplement—but not to supplant—private enterprise, which in the past has tended in Colonial territories to concentrate upon mining enterprises and upon the production of certain export commodities.

The Corporation has already announced the methods it proposes to adopt and also its intention of creating regional organisations for the closer control of its activities in the several Colonial regions. It has already a considerable number of projects under active consideration, and several have been investigated on the spot. It will start some projects this year, although it is realised that the present shortages of certain basic materials must be kept in mind, and that there may be some delays on this account.

Biological Factors

I will now turn to some of the biological factors which have to be taken into account when Colonial development—particularly in Africa—is under consideration.

Population Issues

The increase of populations in many areas, their irregular distribution with consequent pressure, in places, on the land, as well as the tendency of populations to drift to the urban areas must be recognised. These populations are certain to increase further as malaria and other diseases are controlled, and emphasis must therefore be placed on the need for an increased production of foodstuffs for local needs and on occupational diversification.

Tsetse

Several species of tsetse flies occur in the African Continent in areas, which in the aggregate equal 75 times the size of the United Kingdom, and some of these are responsible for the transmission of diseases to man, game and domestic stock. Their occurrence accounts to a considerable extent for the uneven distribution of populations and their domestic animals in many parts of Africa. In Tanganyika alone, tsetse flies occur in over two-thirds of the territory, and whilst trypanosomiasis is under better control, thanks to increased knowledge and the production of better organic compounds with prophylactic and curative properties, outbreaks still occur.

The main effort must be directed to the destruction of the carriers, and the research work which has been carried out during the past twenty years has gradually built up a mass of information which has enabled reclamation work to be satisfactorily carried out. The bionomics of many species have been worked out, and the ecological factors which favour or control the spread of tsetse have been carefully investigated. It has been established that tsetse flies are susceptible to changes in environment brought about by clearing and thinning the bush, and successful reclamations of areas from tsetse have been achieved by bush clearing provided that the subsequent tree growths in the areas so dealt with have been kept in check.

Looking at the picture as a whole, however, the progress of reclamation is very slow and on a very small scale, and in certain parts of Africa there are definite indications of further invasions of territory by tsetse. Large scale clearing operations, such as those being undertaken by the East African Groundnut Scheme may show the way to bring tsetse-infested country more rapidly into economic production, but no one can be satisfied with the present position. This is recognised by the authorities.

It has further been established that under certain conditions tsetse can be controlled by the use of D.D.T. smoke generated and distributed from aircraft, and plans are now well advanced for thorough trials of insecticide dissemination by specially equipped aircraft and helicopters. A summary account of the achievements to date and of the plans made for future research will be found in the Report on Colonial Research 1947–48 recently issued as *Cmd.* 7493.

The wholesale use of the new insecticides is not without danger from a biological point of view—as many useful insects may be eliminated. Careful ecological studies are required and have been considered, but it has so far been impossible to put such investigations

in hand because of the shortage of scientific man-power.

Livestock Diseases

Livestock diseases still remain in many parts of Africa, a factor which acts as a control on the development of animal industries and the establishment of more satisfactory systems of agricultural husbandry. Rinderpest is the most serious of the cattle diseases of an epidemic character, and it still occurs from time to time in several territories despite the excellent work which has been done by the small number of veterinarians in the field. In East Africa it had been hoped that a check on this disease had been satisfactorily achieved, but the recent outbreaks in Tanganyika, in view of the small number of veterinary officers in the field, cannot be lightly disregarded. Progress with mixed agricultural systems and with the improvement in animal husbandry or the development of thriving animal industries are unlikely to be rapid whilst the menace from rinderpest persists.

Locusts

Crop losses of considerable magnitude have been experienced in the past in Africa from swarming locusts, but the results of the patient research of the last twenty years are now being applied and are paying dividends. The extensive campaigns for the control of the Desert Locust in East Africa and the Middle East, which have been in progress during the past six years, are now coming to an end as the countries involved are free of swarms, and in Tanganyika, successful control of the Red Locust has also been achieved. It has indeed been established that locust plagues can now be checked before they assume dangerous proportions provided the outbreak areas are adequately supervised and timely action taken against incipient swarms. Locust control by spraying from aircraft has been effective and this method can be applied satisfactorily against incipient outbreaks.

Termites

Termites, however, still remain unchecked and cause unrecorded losses of considerable magnitude throughout the Colonial Empire. It is high time that steps be taken not only to provide for a survey of the termite position in Colonial territories but also to start planned research. The establishment of an additional post at the Natural History Museum for a specialist to concentrate upon termites has been recommended, but in addition to the establishment of this post it would seem that the advances which have been made through the work of the research teams concentrating upon locusts and tsetse warrant the establishment of a similar team for the scientific study of termites and the evolution of satisfactory control measures against their damage. There is available in the Colonies a considerable amount of local knowledge about termite damage, the resistance of certain hard-wood timbers to attack from certain species and about control measures generally, but this knowledge requires to be brought together and expanded by scientific research.

Pests and Diseases

Pests and diseases of plants and animals are also factors which have always to be kept in mind. I have already referred to the rinderpest disease of livestock, but I need only mention certain virus and fungus diseases, such as the swollen shoot of cacao (which is threatening the cacao industry and with it the whole economy of the Gold Coast), the 'sudden death' of cloves in Zanzibar and Pemba which has already caused the loss of a major part of the clove trees in the former island, and the witches' broom disease of cacao in Trinidad responsible for the decline of that industry, the Panama and leaf spot diseases of bananas—and then pass on to the pests of cotton.

The need for increased supplies of cotton from within the sterling area is great, especially at the present time. Excellent research work has already been done by the Empire Cotton Growing Corporation specialists and by research workers employed by Colonial Governments. Many new types of cotton suitable for different areas and resistant to some of the pests and diseases common in those areas have been evolved, and their cultivation expanded. Crop losses from Jassid and other pests and from certain virus and other diseases have been checked. Stainers are very troublesome in some areas, and they cause damage in crops and crop values. They rarely, however, limit expansion. Certain boll worms definitely have a limiting effect and must always be taken into consideration when expansion of cotton growing is planned. The red boll worm (*Diparopsis Castanea*) is the most limiting. When the climatic regime consists of a single rainy season followed by a long severe dry period there are serious risks in any attempts to grow cotton. The habits of this pest have been fully worked out in the Sudan and in Nyasaland, Mozambique, Southern Rhodesia and South Africa, and it definitely restricts the expansion of cotton growing in large stretches of Central and East and West Africa. Agronomic methods for the diminution of the damage can be effective if rigidly carried out, but the cotton specialists feel that other methods of control—possibly the use of insecticides—will have to be devised before extended cultivation of cotton may be possible

in large sections of the continent. The Empire Cotton Growing Corporation have had in hand a survey of the pest position in the principal cotton growing areas of the Colonial territories in Africa since 1945, and have recently strengthened their entomological staff.

The Importance of Food Supplies

The present world shortage of food supplies is sufficiently well known to make it unnecessary for me to embark upon statistics. We, in Britain, are well aware of the shortages we have to endure at present, and in certain areas of the Colonial Empire the people have not available supplies adequate for satisfactory nutrition.

Generally there is in the Colonial diets an insufficiency of the B-vitamins, and in some places there are definite hungry periods between the seasons—coinciding with the time of the heaviest agricultural work in preparation for the next year's crops—, in others serious shortages when the rains fail, and in others definite protein starvation. In the southern portions of the territories in West Africa the craving for protein food is most marked, and to spend a night with the gangs who go out to trap small rodents in the fields is an experience which cannot be forgotten ; nor can the searching by the women of the village refuse dumps for the larvae of beetles. There is throughout the Colonial Empire a great need for wider variety in the diet and for a much greater consumption of protein foods if extra effort is to be expected in developmental projects. Indeed, it is now slowly beginning to be realised that in their agrarian policies Colonial Governments must give the highest priority to the food needs of their people and to the stimulation of greatly increased production of crop and animal food products.

Fishing

Considerable attention is now being given to the development of fisheries. The fishery resources in the waters of Colonial territories have been neglected too long, and very few Colonial fisheries have reached an advanced stage of exploitation. A wide field is open for development by the application of modern technology.

The first stage requires that the marine resources should be catalogued in the terms of the availability of fish. This involves fishing exploration and the application experimentally of every fish-catching and processing technique which can be brought to bear, so that a direct measure of the availability of fish is obtained in terms of the yield per unit of human and material effort expended in their capture and distribution.

At a later stage, it will be necessary to build up a body of basic scientific knowledge of the fisheries so that the level to which exploitation can safely be developed can be determined.

An ambitious programme of research has been planned by the Colonial Office with the assistance of the Colonial Fisheries Advisory Committee which was formed in 1943. Dr. Hickling, the present Fishery Adviser to the Secretary of State for the Colonies, has achieved much in the last three years.

On the development side we must rely upon the exploratory phase of research, but given a few hard facts, the development agencies will not be backward in making pilot-scale trials and facing financial risks within limits. Practical tests are an urgent need.

The whaling industry has been developed largely as the result of the whale fishery investigations of the ' Discovery ' Committee of the Colonial Office, and this industry is an example of the complete dependence on fundamental oceanography and marine biology. Through this work the vast biological productivity of the southern oceans is made available for human needs, with a reasonable assurance of a maximum sustained production.

As regards fresh water fisheries, it is satisfactory to know that the Fisheries Research Station on Lake Victoria will shortly be completed and that considerable attention is to be given to the practicability of developing fish culture in the Colonial territories. The results of fish farming in the Far East and in Palestine have been examined in detail, and investigations have been made in Nyasaland, Northern Rhodesia, Kenya and Uganda. There are vast possibilities of increasing fish supplies by means of fish farming, but trained personnel is essential, and a scheme is now being prepared by the Colonial Office for the establishment of a training and research centre in Malaya. Far Eastern knowledge of fish farming is greatly in advance of that of other countries.

Mechanical Aids to Colonial Agriculture

Colonial agriculture—the basic industry of most of the Colonial territories—is dependent largely upon peasant production. Plantation enterprises have created important industries responsible for the production of tea, rubber, sugar, tobacco, coconuts, coffee and sisal, and have made increasing use of scientific assistance in their development. They have created crop research stations with the object of increasing efficiency and of dealing with biological problems which face them from time to time. But Colonial production in the main is in the hands of small men—many of whom grow their crops on very small areas, which they move from time to time. The production of foodstuffs for their subsistence

is their primary occupation, even though small holders in certain areas are producers of cacao, coffee, coconuts, cotton, rice and bananas for export and local consumption. In the main their husbandry methods can be greatly improved, and their animal industries are still based on uncontrolled grazing. With the existing tools available to the producers and with the methods in vogue, increased productivity is difficult to achieve.

The requirement at present is to secure better organisation of farming operations and to test the value of fertilisers and the possibility of introducing mechanical aids into the field of Colonial production. The effects of their introduction on the farming economy and the social organisation of the people will also require careful study and investigation, as their introduction will necessitate farming units of a larger size whether cultivated individually or communally. The possibilities of increased erosion must not be overlooked, and there may be additional dangers from pests and diseases. Useful lessons will doubtless be learnt from the East African Groundnut Scheme.

The East African Groundnut Scheme

This scheme has been the subject of much optimistic comment and also considerable criticism. There was no doubt that the world shortage of edible oils made it essential that the project should be undertaken. It will have an important influence on the agriculture of Tanganyika and on Colonial development generally. I have recently had an opportunity of paying a short visit to the Kongwa area—the first to be opened. The speed at which equipment could be assembled in the field for bush clearing, cultivation and harvesting was much slower than had been expected. Much of the equipment had to be reconditioned, some had to be modified and some new implements had to be evolved. In the face of these difficulties and disappointments the achievements up to date have been remarkable, and I was greatly impressed by the enthusiasm of the workers on the project. Many of the technical difficulties on the mechanical side for dealing with the clearing of the Kongwa area and with cultivation have now been overcome, and those responsible are to be congratulated upon their achievements. I was also impressed by the way in which East Africans—after initial training—were handling mechanical bush-clearing equipment.

In the earlier discussions on the scheme I expressed the view that the speed of getting the scheme into operation would be slower than was forecast; that unforeseen difficulties had to be expected and allowed for—this is always the case in pioneering ventures—that crop rotations would require to be evolved if soil texture was to be maintained, erosion reduced and the land kept in 'good heart,' and that the hazards from pests and diseases were considerable.

The groundnuts and other crops grown in the Kongwa area this year have been free from any serious attacks from pests and diseases, apart from damage to the sorghums in the experimental area. There has been some damage to certain groundnut varieties from wild pig, but no occurrence of the virus disease—rosette—has been seen. Rosette disease is capable of causing serious losses, and it is very necessary that the research work undertaken by the scheme should be well in advance of requirements, so that outbreaks of rosette and of other pests and diseases can be met when they arise.

An extensive programme of field trials to investigate crop rotations, fertiliser needs, cultivation methods and groundnut varieties, as well as a large series of observation plots with a wide range of crops have been put into effect this year and valuable lessons have already been learnt. This work has been given the highest priority, and steps have recently been taken to increase the scientific staff. It is to be hoped that arrangements will also be made for the testing of a wide range of groundnut varieties for resistance and immunity to rosette disease in an area of the territory where the disease occurs in some abundance, since, in my view, such work can only be regarded as a necessary insurance.

Conclusion

I have attempted to give a review of some biological aspects concerning Colonial Development. Time does not permit this to be comprehensive, but it is clear that although a considerable increase of basic knowledge has resulted from the Colonial Research work, it is very necessary to see that it is applied. The application of the results of research still leaves much to be desired and this state of affairs should be remedied.

I have alluded to the necessity for special attention to be given to termites and I have stated that it has been recommended that a post should be created at the Natural History Museum to deal with scientific problems concerning termites and their control. There are other additions to the scientific staff of the Natural History Museum which are desirable. It is also essential that early steps should be taken to enable Kew to produce the Flora of East Africa. No such Flora exists at the present time and it is important that this should be put in hand as early as possible as it is very necessary not only for ecological work, but also for the use of biologists in all spheres of activity in that region.

HUMAN BLOOD-GROUPS

A Report of a Symposium[1]

Edited by

Prof. K. MATHER

Blood-Groups and Human Genetics

by

Dr. J. A. Fraser Roberts

Observations on the human blood-groups are made by serologists, a numerically small body of scientific workers, doing highly technical laboratory work. The results they obtain, however, are of wide importance in the fields of human genetics, of genetics as a whole and of anthropology. I am glad that someone who is not a serologist has been selected to give this introductory paper, for it enables me to express the admiration we all feel for the truly brilliant work of recent years. Seldom indeed in the history of biology can progress in any subject have been so rapid and so sure.

The blood-groups are determined by antigens carried on the red cells, and the presence of the antigens is determined by corresponding genes. The presence or absence of particular antigens is of vast practical importance. During the war millions of donations of blood were required. Even in peace-time the number of blood-donors needed in England and Wales is of the order of 500,000. Also of great importance is haemolytic disease, which makes a substantial contribution to infant morbidity and mortality. As a consequence, records have accumulated on a scale vastly greater than would ever be possible in academic research. One of the arguments in favour of the Health Bill of 1912 was that the records could be used for scientific purposes, and provision was made for this ; but these hopes were not realised ; and actually, as far as I am aware, no use has been made of them from that day to this. For, unfortunately, it is very rarely indeed that administrative health records are of any use for scientific analysis. There are a few exceptions however—a very few—and of these perhaps the most brilliant is the blood-groups. Records compiled and maintained for purely practical and administrative reasons have been successfully used for advancing scientific knowledge, with the striking result that far more is known about geographical variations in the frequencies of some of the blood-group genes than about geographical variations in the frequencies of any other genes whatsoever, whether plant or animal. One reason for this success is, of course, that the categories are few, rigid and unequivocal. Statistics of human mortality are of immense scientific importance, but this is largely because, statistically speaking, human beings are by international agreement only allowed to die in relatively few and most explicitly defined ways. In the blood-groups there was no need to create this artificial simplicity ; it already existed as a fact of nature.

It is largely the simplicity of the blood-groups, speaking genetically, of course, and not serologically, that makes them so valuable. In the first place, they are one hundred per cent. inherited, and owe nothing to environment. This is not true of many of the other measurements of anthropology. Cranial index, for example, may be affected by environmental factors. I have seen a pair of undoubtedly identical twin boys with a similar cranial capacity, it is true, but one had a relatively long, narrow head and the other a relatively short, broad one.

In the second place, not only is heredity solely responsible, but it is simple heredity. Now it is very difficult to find normal, common, human traits whose heredity is simple. Stature, in a civilised community with no gross malnutrition, is very largely genetically determined, but inheritance is multifactorial and hence analysis is much more intricate. In contrast, with the qualification to be made in a moment, this is a matter of one gene, one corresponding antigen.

But the genetic convenience of the human blood-groups does not stop there. In dealing with individual genes, it is, of course, dominance that complicates genetic analysis ; it is a very great simplification if all genotypes can be specified by direct observation. While some of the blood-group genes do show dominance and recessiveness, with many dominance is absent or partial, so that the heterozygote can be distinguished serologically from both the homozygotes. The blood-groups themselves provide a striking illustration of the value of this simplification. It took more than ten years to settle the

[1] Papers read on September 13, 1948, at the Meeting of the British Association in Brighton.

genetics of the *ABO* system, in which the *A* and *B* genes are dominant to *O* (though, of course, it would not take so long to-day). In contrast, the genetics of the much more intricate Rhesus system, where there is no complete dominance, has been promptly elucidated step by step with each succeeding serological discovery.

Two final points of importance to anthropology: as Professor Haldane has pointed out, a trait may be genetic (even simply genetic), yet its usefulness may be limited because it is strongly adaptive, as, for example, is no doubt true of skin colour. The character of a population may thus be greatly altered by selective forces within comparatively few generations. There is, however, no evidence that the possession of a particular antigen might be more favourable in one environment than in another. Hence the blood-groups are especially fitted to throw light on the moderately remote as well as merely upon the very recent origins of mankind. The last point is the obvious one: that some of the antigens show wide differences in frequency in different races. For all these reasons the blood-groups provide what are probably the most valuable anthropometric measurements we possess.

Those of us who are geneticists or anthropologists, or who have a general interest in biology, are very ready to take the work of the serologists on trust. The most we can do is to learn, in outline, something of the methods they use. But the results that especially interest us, once they have been worked out, are simple enough. A single antigen, a corresponding single gene, often no complete dominance—what could be simpler than that? But there are two complications or extensions which must be understood if our knowledge of the genetics of the blood-groups is to be brought up to date: one, an old and familiar concept in genetic history; the other, very new and curious.

The first is the occurrence of systems of multiple allelomorphic genes. Corresponding to a particular locus on a particular chromosome pair we find three, four, or more alternative genes. Thus, at the particular locus of the *ABO* system we may have gene *O*, gene A_1, gene A_2, gene A_3 (which is very rare), or gene *B*. Each individual possesses two of these genes, either the same or different.

The second complication is, as I have said, much newer and much more curious. Early in the investigation of the Rhesus system it was found that what behaved as a unit in hereditary transmission, and was, therefore, presumably a single gene, determined the presence on the red cells not of a single antigen but of a constellation of antigens, reacting with several different anti-sera. Moreover, the patterns of the reactions determined by different single genes overlapped. Thus one gene determined reactions with anti-sera 1, 2, and 3, but not with 4; another, reactions with 2, 3 and 4, but not with 1; another, reactions with 4 only, and so on. This was all pretty complicated genetically and the papers of those days make heavy reading. Then, four years ago, came Professor R. A. Fisher's synthesis, and with it illumination for those of us who are not serologists. It is one of the particular merits of Professor Fisher's scheme that it makes the genetics of the Rhesus system easy to understand; but, of course, this is only an incidental advantage. The hypothesis made predictions that have been brilliantly confirmed; it resolved difficulties that previously existed and has gone on resolving new ones; but at the moment it is to the simplification of the genetics that I want to refer.

Professor Fisher postulated not a single locus with a single gene, but three loci situated very close together on the chromosome. At each there occurs either one or the other of a pair of genes; at the first either *C* or *c*; at the second either *D* or *d*; at the third either *E* or *e*. Each determines the presence on the red cells of a corresponding antigen. It is supposed that the three loci are so close together that crossing-over between them practically never occurs (it has not yet been observed). The result, then, is that a constellation of three individual genes, determining the presence of three antigens, behaves as a unit in inheritance.

There are eight possible compound units, all of which have now duly appeared. Three of them, *CDe*, *cde* and *cDE*, are very common in our population. Gene *cDe* is, exceptionally, common in negroes; *cde*, common amongst us, is absent in the aboriginal populations of America and Australia and also amongst the Chinese and Japanese.

Finally, we must put the two complications together. It has been found that at two of the three loci there occur not pairs of genes but systems of multiple allelomorphs. At the *C* locus we may have *C*, *c*, or, much more rarely, C^w; at the *D* locus *D*, *d*, or, much more rarely, D^u. This of course greatly increases the number of possible compound genes, as you will be hearing from Dr. Race. Armed, then, with a knowledge of these two complications we can remain undefeated by the worst the serologists have yet been able to do to the Rhesus system (and now to the *MN* system too), and can readily apply our knowledge to genetic transmission and to the study of racial and geographical variations.

Before concluding I want to say a word, mainly historical, about racial and geographical variations in the frequencies of the *ABO* genes, as, apart from Dr. Darlington's paper, which deals with a very special and very remarkable aspect of these variations, it is a subject not covered by subsequent speakers.

In June 1918 there occurred an event of historic importance, when the Zurich serologists, Ludwig Hirschfeld and Hanka Hirschfeld, read a paper to the Medical Society of Salonika. They had been working in the allied army in Macedonia, which was composed of men of many races, and were able to demonstrate for the first time, certainly in any systematic way, that the human species shows very wide differences in the frequencies of the *ABO* blood-group genes. The following year their paper appeared in the *Lancet*, and it is remarkable how far this single contribution foreshadowed the world-wide distribution we know to-day.

Following the Hirschfelds, the outline was steadily filled in. Two well-known maps, published by Boyd in 1939, show the distribution of genes *B* and *A*. From them we can see the clear indication of the outward spread of *B* from Central Asia, with, possibly, a secondary origin in Africa. The distribution of gene *A* is more complicated and Professor Haldane's suggestion undoubtedly provides the best explanation. It supposes that at a time when man was a rare animal many small, isolated or semi-isolated tribes were by chance either predominantly of group *O* or of group *A*. Increase in population, migration and intercrossing have given us the picture we see to-day.

The vast requirements of the transfusion services during the war years have added much more detail since 1939. I have time to refer briefly only to what has been learned about the British Isles. In our country there seems to be little variation in *B*, the gene frequency being very close to 6 per cent. in England. But the relative proportions of *O* and *A* differ fairly widely in different areas. The proportion of persons falling into blood-group *A* is at a maximum, of about 44 per cent., in southern England. In the north of England it is 40 per cent.; in Scotland and Ireland 36 per cent. One ethnological lesson was pointed out by Fisher and Taylor. The Scandinavians of to-day have the highest *A* in Europe, yet Iceland, colonised from Scandinavia, and Scotland, much affected by Scandinavian influences, have the lowest *A* in Europe. It would thus appear that the colonisers of Viking times were not the ancestors of the modern Scandinavians, who presumably derive principally from subsequent waves of immigration. North Wales shares high *O* and low *A* with Scotland and Ireland, but, rather remarkably, South Wales resembles southern England. Cornwall, too, shows no difference from the rest of southern England.

Thus the gradients of *ABO* gene frequency have been broadly mapped out in the British Isles, but one would now like to see the work carried on to the next stage. Underlying the broad pattern might there not be local pockets of variation? Some of the big wartime counts were ample enough, but it would not have been safe to use them for this purpose. The reason is that in wartime the rapid mass registration and preliminary grouping of donors inevitably entailed a proportion of errors. These were not numerous enough to prejudice broad comparisons, but it was possible that a non-random distribution of errors might have simulated local variations.

To-day the position is different; there is time for meticulous checking and record-keeping; donors need not be placed on the panel until they are actually bled and the donated blood carefully grouped. I am glad to say that with the help of a grant from the Nuffield Foundation, and the generous co-operation of the National Blood Transfusion Service and its Regional Officers, a pilot enquiry has been started. This will be carried out mainly in the Northern region of the Service, which comprises the counties of Northumberland, Durham, Westmorland, Cumberland and the North Riding of Yorkshire. When this project is completed it will, we hope, be possible to decide whether local and perhaps some other variations exist or not. It will also tell us how to make the best use of existing and future records. And so it may be hoped that the story of racial and geographical variation in the frequencies of the blood-groups, already unique in genetics and anthropology, may be carried yet a stage further.

The Multiplicity of Blood-Groups in Man

by

Dr. R. R. Race

Towards the end of the last century it was noticed that if red blood cells of an animal of one species were mixed with serum from an animal of another species clumping, or agglutination, of the red cells usually occurred. The phenomenon was recognised as being very similar to that which followed the mixing of bacteria with certain immune sera. The similarity suggested that the clumping of the red cells was due, like that of the bacteria, to antigens on their surface uniting with antibodies in the serum. That is to say, the phenomonen was almost immediately recognised

as being immunological in nature. Had there been no vast knowledge of bacterial immunity already in existence the fundamentals of the science of immunology could have been built up from the behaviour of red blood cells and serum. As it was, the existing principles of bacterial immunology could be applied to red cells and serum and knowledge of blood-groups was therefore rapidly advanced.

In 1900, not long after the observation of the effect of serum of one species on the red cells of another, Landsteiner observed that the red cells of certain human beings were agglutinated by the serum of other human beings ; and so the existence of different blood-groups within a species was recognised. There are now known to be at least 7 different systems of blood-groups in man. Each group depends on antigens on the red cell. Of the antigens we know very little ; of the equivalent antibody, found naturally, or made, in a serum, we know perhaps less. But, of what happens when blood-group antigen and blood-group antibody combine, we know a great deal. The union of antigen, on the red cell, and antibody in the serum, is presumably on a molecular level of size, but the fact that it has occurred is apparent to the naked eye, for the red cells involved stick to each other in large clumps, or agglutinates. The red cells which may be looked upon as merely carriers of the antigen, act as indicators of this interaction. If the red cells lack the particular antigen, when mixed with the serum containing the antibody they are not agglutinated but remain evenly suspended.

Blood group tests are very simple and consist of adding a small volume of a suspension of the cells to be grouped to a small volume of serum containing the antibody to the particular antigen being tested for : if the antigen is present, agglutination of the red cells occurs. The only difficulty about blood-grouping is one of supply of antisera. Some antibodies such as those for the *ABO* groups are easily found, for they occur naturally in the serum of normal people. Other antibodies such as those for the Rhesus (or *Rh*) groups only occur when certain people have been stimulated to produce them. The two main stimuli are transfusions of blood and pregnancy.

Blood-group antigens are inherited in a very simple way by means of genes which are given the same names as the antigens. Blood-group genes and antigens are almost synonymous. If the gene is present the antigen is present, apparently uninfluenced by climate, diet, health, or by other genes in the body. A person does not posess a blood-group gene if neither of his parents has it, and he must pass on one or other of the two members which he possesses of each system of genes to each of his children.

In any system of blood-groups there are usually more genetically different types, or genotypes as they are called, than can be distinguished by our tests. The groups we can distinguish by testing are called phenotypes.

In the *ABO* system there are for example 10 genetically distinct types of blood, but we can by serological tests only recognise 6 different types. This distinction holds in varying degrees in the other groups. As knowledge and techniques improve, however, the difference tends to be obliterated : the number of phenotypes more closely approaches that of the genotypes.

The only other blood-group system which I wish to speak of in any detail is that called *Rh*. This group depends not on one gene on a chromosome like *ABO* but of three closely or absolutely linked genes.

The system of *Rh* antigens and antibodies may be represented thus.

Every *Rh* chromsome has one of each of the *C–c, D–d, E–e*, three pairs of alternatives, so that there are the 8 possible combinations on a chromosome. The *Rh* group of a person will depend on two such chromosomes. If the person receives say *CDe* from both parents he will have only 3 different *Rh* antigens. If he receives say *CDE* from one parent and *cde* from the other then he will have 6 different *Rh* antigens. Thus 3 is the minimum and 6 the maximum different *Rh* antigens that one person can have. In practice the situation is somewhat more elaborate than this, for there are further alternatives of *C* and *D*, all of them however, rather rare. As in the *ABO* groups the frequencies of the different forms vary in different races. In England *CDe* is the commonest and *CdE* the rarest form.

The interaction of the *Rh* antigens and antibodies were at one time most bewildering, but the recognition of this pattern, early in 1944 by Professor Fisher immediately made the interactions understandable and shewed them to be extremely simple.

It is interesting to note that when Fisher recognised the basic structure of these groups *d* and *e* and their antibodies, which his theory demanded, were not known to exist but all their interactions were predicted. A year later anti-*e* was found by Dr. Mourant in England, and anti-*d* was duly found in the United States, in Boston and in Dallas. The combination *CdE* was also predicted and this has been found twice, first in Louvain and again in New York. Such successful prediction must be rare in biology

Before listing the blood-group systems so far known I should point out that the genes for all of them are thought to be on different

chromosome pairs. That is to say, there is no evidence of any of the groups being inherited together, or linked ; they sort themselves out independently of each other. For example if a person is A_1B MN he will hand on to the next generation A_1 and M as often as A_1 and N, B and M as often as B and N. And so with the other blood-groups.

The 7 systems of blood-groups are shown in the Table :—

The 7 systems of blood-groups	Phenotypes i.e. serologically recognisable groups	Genotypes i.e. genetically different groups
A_1A_2BO . .	6	10
MNS . . .	6	10
P . . .	2	3
Rh . . .	41	120
Lutheran . .	2	3
Lewis . .	2	3
Kell . . .	2	3
Number of possible different combinations . . .	23,616	972,000

The commonest combination in England includes only 2 per cent of bloods. The rarest combination would be so infrequent that it may never have formed the blood of an Englishman.

Miss Sanger has tested 250 whites, from Boston and London, for 6 of these groups (tests for Lutheran being ruled out by lack of serum) and in them she found 179 different types of blood, of which :

133	occurred	only once
29	,,	twice
10	,,	three times
6	,,	four times
1	,,	five times

Thus 53 per cent. of the bloods were unique in their combinations of groups, and 76 per cent. were either unique or could be confused with the blood of only one other person from the 250.

It would only require the discovery of 3 or 4 more blood-groups to make the 250 samples all unique in their combinations. The nearer to equal halves into which a new group splits the population the more useful it will be.

At least 2 other groups are known, but these I have not mentioned because the antigens which characterise them are very rare, having been observed only in the families in which they were discovered, while all other unrelated persons tested have lacked the antigen. Such rare groups do not play a useful part in human genetics.

Another way of appreciating the individuality of blood-groups lies in the consideration of how seldom the children of any one family possess the same blood-groups.

Miss Sanger has tested 20 families for the 6 blood groups (again excluding Lutheran). Each family had 2 or more children, and there were 56 children in all. In only 3 families were 2 children the same in their blood groups.

One of the better known applications of the blood-groups is their use in cases of disputed paternity. If all the groups I have discussed were tested in such cases, well over half the men wrongfully accused of paternity could be exonerated.

But an infinitely more important application will be in genetical research by the use of blood-groups genes as markers for chromosomes. By observing that some other inherited character travels through the generations together with a certain blood group it will be possible to assign the gene for that character to a particular chromosome and perhaps to determine its actual position on that chromosome. Ultimately it may be possible to produce a map of the human chromosomes with the position of hundreds of genes charted, a map such as that which has already been made for *Drosophila*.

Finally I should point out that we have not yet reached the end of the story, for it seems probable that many more blood groups remain to be discovered. The number of known groups has more than doubled in the last 10 years. Owing to the very widespread attention now given to the blood groups, as a result of the clinical importance of the *Rh* genes, we can have every hope that progress will continue to be rapid.

Blood and Speech

by

Dr. C. D. Darlington, F.R.S.

The achievement of philology has been, first, to show the family relationships of languages from which evolutionary changes could be inferred and, secondly, to show certain of the laws by which these changes take place. Some of these show the regular relationship of cause and effect over great areas and great periods of time, but others point to differences amongst men. Such are the principles of the individuality of speech, the local determination of dialect, and the instability of newly transferred or imposed languages. The causes of these differences, no less than the causes of the similarities which men show in their speech, must be partly genetic. It is these genetic components whose actions I wish to examine.

Our first step must be to sort out changes in language itself into elements much as, in genetic experiments, we sort out changes of phenotype into the effects of heredity and environment. For this purpose language may be taken as consisting of three elements :

the first is the scarcely changing basis, the stems of words, whose constancy is used in tracing the genealogy of languages. The second is a slowly changing part, the grammar, whose large changes follow a cycle merely differing in speed in different members of the Indo-European family and therefore providing poor evidence of genetic control. The third is the most rapidly changing part, that of sound, whose changes follow different lines in every language and even dialect. Phonetics is evidently the most promising starting-point.

Sound changes are of two kinds. The first may be described as changes of *apportionment* such as are covered by shifts and dissimilations. They often have, like grammatical changes, a cyclical and hence mechanical character depending on one another and on accent changes ; they are therefore again likely to be most indirectly related to the genetic conditions. The second kind of sound change is found in what we may call *complement*, or the total sound equipment of a people. Within the European languages there are certain clear divergencies in complement, as in H, TH and KH, while between them and more remote languages much greater differences occur. Change of complement can scarcely depend on fortuitous mechanical conditions. It is, on the other hand, most likely to depend on the inherent capacities of individuals to make the sounds concerned. It is with changes of complement, therefore, that we ought to begin our investigation.

It is, further, in Europe that we have the best chances of establishing our case, on account of our much greater knowledge of the present and past relationships of the peoples and languages of this region than of any other.

The mechanism concerned is the apparatus of voice production. It shows the highest degree of variation in man. Although family resemblances are high, no two of us, apart from identical twins, are alike in voice. Some differences depend on hard external structure ; others, like Sturtevant's difference in tongue rolling, no doubt depend on less obvious muscular and nervous control. Now it is a principle that all variable characters of a species (apart from those like sex and caste which are co-operative) will also vary absolutely or relatively, as between its subordinate endogamous groups, its races or tribes. There is therefore no reason to doubt that the observed differences in capacity for sound production amongst different races and nations of man have, in part, a genetic basis.

Genetics would lead us to assume too that we have in all parts of Europe a mixture of individuals, of genotypes whose differences fall into two types of spatial variation: (i) *clinal*, to use Huxley's expression, that is, showing statistical gradients in respect of the proportions of individuals with contrasting characters : (ii) *tribal* or broken up into discontinuous groups by barriers to mating. (See Darlington & Mather : *The Elements of Genetics*, 1949.)

The genetic differences in capacity for sound production need be only very slight. They need merely suffice to establish *preferences* on a principle of economy or ease in speech which expresses itself in many linguistic rules. For example, by the principle of consonantal dissimilation one consonant of a group is altered to make the group as a whole easier to articulate. The uniformity of the changes that result has been pointed out in the past. This uniformity arises from a uniform difficulty for one people. What we are now concerned with are difficulties greater for one people than for another, difficulties which will lead to preferences in one and not in another, and hence to divergence.

Many will object at this point that education will overcome these differences or difficulties. For a sufficiently insensitive ear this can appear to be true. But in fact the reverse argument is more important. The force of unconscious imitation is the most powerful discipline known to free peoples. We see this best in slave-owning societies, such as that of the southern United States, where the owners and the slaves, genetically dissimilar, by imitating one another, have produced in the course of 300 years a convenient intermediate compromise. By seeking their lowest common denominator, two non-combining groups in one community can thus reduce (but not abolish) the appearance of those limitations of speech which are inherent in each. But nearly all languages are produced by communities composed of a single combining group. Imitation within communities will then be between genetically similar individuals and will therefore serve to magnify differences between communities rather than reduce them. A slight, and indeed only statistically identifiable, genetic difference will establish a linguistic difference and, secondarily or mechanically a linguistic divergence.

Genetic limitations and preferences would be expected to express themselves at all three levels, the individual, the group and the race or nation. The most direct expression of genetic character is seen of course in the individual. Impediments of speech are universal in infants and different for every infant in each family. Most of these impediments are overcome before maturity but a few remain in the adult, and particular impediments are

characteristic of particular peoples speaking particular languages, their own or others.

The group expresses its genetic character in dialect. In this respect dialect stands between the imaginary free speech of an individual and the standard or high language of a civilised nation. Dialect is most significant genetically: the group which makes it is, in the first place, as close as we can get to a mating group, a unit of genetic recombination; in the second place, they are a group unrestrained by the conservative force of the written word with its traditional articulation. The effect of inbreeding in promoting the proliferation of dialects is autocatalytic, for dialects, once formed, reduce outbreeding.

When we reach the language level, what interests us is a language newly imposed on a people. Its mechanics are revealed by the changes the negro slave has made in the different languages of his masters. Confronted with French his preference asserted itself, whether in rhythm or sound, by breaking it down into Creole, a new language. Confronted with English and Spanish he merely modified the sounds. In both cases it is no doubt the tongue which prefers and adopts and the ear which later approves, the easy course.

When we take a longer view, we see the imposed language revealing genetic action in two ways, by its divergence and by its instability. The new speakers change a language to fit their preference in sound production. And when they themselves are genetically mixed, as they usually are, they themselves change and the language remains unstable for a long time. To the first cause we have to attribute the diversification of the Romance languages, and to the second, the instability of English or early Latin in contrast to the stability of Persian or Polynesian.

The European sound complement varies most clearly, and the history of the variation can be traced most accurately, in respect of the TH sound. I therefore propose to use it as a pilot test, to illustrate methods and principles.

The present distribution of TH seems to be confined to the periphery of the Eurasian continent. It exists in three zones—the European, the Arabic, the Dravidian with Burmo-Siamese; or we might say approximately the Christian, the Islamic, and the Buddhist. The TH character thus overrides the genealogical division of language at the same time that it shows a certain historio-geographical consistency.

Our historical and pre-historical knowledge throws light at least on the first two of these zones. Common ancestors whether of languages or of peoples are no doubt more heterogeneous than we are led to suppose. But the common ancestral Indo-European language which seems to have arisen in the Danube basin seems also to have had the TH sound. Its western expansion brought it into contact with a TH-speaking Basque zone stretching, as place-names indicate, from Genoa to Bordeaux and Lisbon. In the east it met non-TH speakers including the forbears of the modern Finnish, Turkish and Paleosiberian groups. In consequence TH seems already to have changed into an aspirated dental in Sanskrit and to have disappeared in the whole eastern and central Aryan groups—Slavonic, Georgian, Armenian, Persian, Hindustani, etc.

The great Aryan expansion was followed in historical times, as we know, by a series of reverse movements into Europe of non-TH-speakers. Although, outside Britain and the Balkans, these migrations have not greatly altered the distribution of languages, they must have changed the racial composition of the speakers of those languages. It is not surprising, therefore, that the TH sound was lost in a band of invaded countries. The change was pre-historic in eastern Europe. Elsewhere it can be dated. It began in Italy and moved north through France and Germany to Sweden in the period from 300 B.C. to A.D. 1400. The Celtic, Gothic, Illyrian, Venetic, Etruscan and Basque TH sounds were driven out of all these countries, with or without the languages to which they were attached. The prestige of a governing class had suppressed the TH sound in educated usage in the Latin-speaking part of the Roman Empire. After the overthrow of that empire, western Europe was confused phonetically as in other respects. There was a new sorting out of sounds. The whole of the Carolingian Empire lost its TH. In France there were flickerings of TH as seen in the French version of the Serments de Strasbourg in 842. And to-day, according to van Ginneken, we find it in Savoie and Dauphiné and, in the Basque combination of TTH in a region of Poitou. Beyond the Rhine TH receded in a wave which began in the ninth century in the south of Germany, reached the Baltic in the thirteenth, and submerged Friesland and most of Scandinavia in the fourteenth century.

The fringe in which the TH sound remains to-day runs from Iceland through Britain to Spain and Greece. Again we see that it overrides the boundaries of linguistic genealogy. It unites Teutonic and Celtic in the north-west, Latin and Euskarian in the south-west, Greek and Albanian in the south. The phonetic unity makes itself heard through the verbal divergence.[1]

[1] See Darlington, C. D., 1947. *The Genetic Component of Language*: HEREDITY 1: 269–286.

In two areas the changes of TH repay more detailed study. In the British area we see a gradient or cline. Its maxima are in Iceland and Ireland, recalling an ancient commerce in women. It falls in dialect through Scotland and Wales to the north of England where the level is irregular but in general lower on the east side. It reaches a minimum in England nearest to the non-TH coast of France and also where Celtic place-names are fewest. In western Norway and Denmark it is reduced from a phoneme to a consonantal variable and indeed is entirely lost in most Fünen and Jutland dialects. Finally in Breton it expires altogether but it has reappeared (in place of *r*) in West Jersey. Historically there has perhaps been some decline in the TH of standard English since King Alfred's time.

These transitions in space and time reinforce what the general map of Europe tells us, namely, that TH is being pushed westwards as an effect of migration and without respect to the language, Celtic or Teutonic, which carries it.

The second most important area is that of the Iberian pensinsula. Climatic and geographical as well as linguistic and historical evidence suggests that this region has been especially resistant to racial intrusion. The Latin language and later the rule of the Caliphate were successfully imposed on the people by numerically weak invaders. These two impositions by small governing classes assisted one another in suppressing for the time being the primitive TH sound which still survived in Basque. But in the central mass of Spain from the Asturias to Andalusia the racial character of the people, freed from foreign rule, reasserted itself. One hundred and fifty years after the Moors had been driven out TH reappeared. It did so in different ways in different parts. In Castille, about 1620, *c*, *z*, and the final *d* came to be pronounced as TH. In Andalusia *s* underwent the same change. The preference was the same, but it expressed itself in different ways by etymological standards just as it does in the comparison of London, Manchester and Dublin.

Although the TH distribution is peripheral in Europe (and Asia), there are, outside the TH ring, two vestiges of what we may call an anti-TH zone. The first and strongest development is that already mentioned in the west of the Peninsula, in Portugal and Galicia where a voiced TH occurs only as a consonantal variable in certain dialects and where the Castillian *c* is unknown. The second is in the west of Ireland. It may be seen equally in the official Erse and in pockets of dialect from Kerry in the sout'west to Sligo in the nort'west. It seems to continue the anti-TH wave along the Atlantic fringe and may perhaps represent the tail-end of an ancient society which, prior to 400 B.C., ran along the coast from Africa and derived from the cultural relations that were so strongly developed in the Megalithic period.

Summing up : the distribution of TH in Europe is intelligible in terms of the available evidence from history and pre-history including our knowledge of place-names and the inferences of the origin of the Indo-European system of languages in central Europe. It favours a greater stability of populations than most historians and philologists have been inclined to assume. And it suggests that the mass of the people ultimately come to express their genetic character by the sounds of their language even when a governing class is able to impose the word basis. The value of TH in this consideration is merely that the European populations are mostly close to the threshold which divides its expression from its suppression and are consequently apt to change from one to the other under the influence of migration and conquest. It can therefore be used as a marker to indicate gradients in the population of the whole continent through its frequency, its existence as a phoneme, and its time of origin or extinction. Such *gradients* correspond to the clines which genetics recognises as characteristics of the natural geographical populations of polymorphic species.

The question is now as to whether any other genetic gradients in man agree with that of TH. A character is needed with a comparable appearance of selective neutrality.

We may regard the *A*, *B*, and *O* blood group genes as possible markers of three homologous segments of chromosome which are near neutrality in effect. Since the three are independent, in the sense that each has no single alternative, the percentages of the different types of chromosome *A*, *B*, or *O* in the population of each region of Europe give three frequency-maps, showing contours and gradients. For small and backward regions such blood group maps are bound to be defective as yet, but they are accurate within the necessary one per cent. for the large and advanced ones. Amongst them the *O* group map (see HEREDITY 1, page 279) shows the kind of arrangement with the history of migrations that we are looking for. In general it suggests a movement from the east driving *O* into the periphery. Its contours enable us to divide Europe into three *O*-genes zones :—

(i) A peripheral zone from Iceland to Greece with 65 to 75 per cent.

(ii) An intermediate zone from Sweden to France with 61·5 to 64·5 per cent.

(iii) Two zones, a main eastern zone and the Portuguese corner, with 61 per cent. or less.

What relation have these zones with TH distribution? The first zone comprises all the TH-positive countries. The second zone comprises nearly all those countries which had TH and have now lost it. The third zone comprises those countries which have not had any recorded pronunciation of TH during the last 2000 or 3000 years.

The agreement between blood group and phonetic zones is complete except for Italy and Holland, which are 2 or 3 per cent. over 65. Their peoples should not therefore have lost their TH as Italy did already at the time when the Latin language replaced the Greek, Celtic, Venetic and Etruscan tongues (100–400 B.C.), and as Holland did 1000 years later.

The salient feature of this agreement is perhaps the Portuguese depression. But no less significant are those finer details which can be detected only in Britain. Here the *O* cline crosses the island in close keeping with the TH position in dialect, reaching its lowest level in the south-east. In Europe as a whole the *O* contours, like the TH zones, agree with the distribution of the great language families only in so far as these agree with our historic and pre-historic knowledge of migrations.

Thus the *O* and TH maps agree more closely than the apparently confused history of Europe would seem to justify us in predicting. The *isogens* are almost exactly equatable with the *isophons*.

We can now have little doubt that genes act on speech. In asking ourselves the quite independent question of how they do so, however, we must remember that in addition to the strictly genetic there is also the social aspect.

This social aspect of the problem of speech has already been the subject of expert study, but with the genetic situation in mind we can interpret the results with more confidence and express them with more precision. Clearly the more variation there is amongst individuals (owing to hybridisation) the more unstable their language will become. And the more unstable a language, the more choice every maturing individual will have amongst alternative sounds to use. These sounds will differ in their local, their social, and their age classes. In making this choice the differing genotypes will have different parts to play. Further, the instability of the language will arise from a genetic difference between the people who made the language and the people who are now using it.

This view is an expression of the genetic axiom that the properties of individuals are determined by the reaction of genotype and environment. But the axiom is modified by a special circumstance, namely, that the genotypes of individuals themselves interact to produce an environment by an integration in space and an accumulation in time. This environment is what we call culture. The discontinuities between nations and between languages that we see in Europe are the steps cut in continuous genetic slopes by discontinuous cultures.

The combination of methods and assumptions I have used for a selected and apparently trivial comparison gives us the means of opening a new field of enquiry. It is a field of incomparable richness for the study of man. It can provide a co-ordinating hypothesis capable of advancing the studies of language, of human genetics, of society and of culture in general, both now and before recorded history. It can provide a first means of evaluating the modes of integration of the masses of dissimilar genotypes which constitute classes, races and nations, modes of integration which underlie the development of all human culture. In doing these things its discipline offers a corrective to the ingenuous theories (or fairy tales) which in the past have done less to help science than to embroil nations. And it requires neither the repudiation nor the exaltation of race, but assumes a continuity underlying the tribal variation of man which more superficial methods have overlooked or disowned.

The Ethnological Distribution of the *Rh* and *MN* Blood-Groups.

by

Dr. A. E. Mourant

While in an area the size of the British Isles the classical or *ABO* blood-groups can give useful information regarding the mixing of racial elements, the distribution of the *Rh* and *MN* groups among different populations is best seen if we consider the world as a whole. Compared with our knowledge of the distribution of the *ABO* groups we know very little about *MN* and much less about *Rh*. Further research will enable both to contribute to a new objective classification of mankind, a classification free from preconceived myths of 'Race,' but the *Rh* classification looks the more promising of the two.

Over nearly the whole world we find the frequencies of the *MN* groups almost constant, with a rise of *M* above the general level in the Indians of Asia, the North American Indians and the Eskimos. There is a slight rise of *M* in the Baltic peoples too. *N* rises above the general level in the Ainus of Japan, the Papuans and the Australian aborigines.

These facts bear little relation to what is known on other grounds, or guessed, regarding the affinities of the peoples concerned.

The *Rh* system is by far the most complex of all the known blood-group systems and for that among other reasons *Rh* testing is difficult, but the results are likely to throw considerable light on racial relationships. The major division of mankind is into *Rh*-positives whose genetic formula is *DD* or *Dd* and *Rh*-negatives who are *dd*. Various other genes can be combined with *D* or *d* giving rise to a wide variety of subgroups. Most people not of European origin are *Rh* positive, but the closely linked chromosomic combinations *CDe* and *cDE* are the principal ones found in Asia, the Pacific area and among the American Indians. African negroes are preponderantly *cDe* which marks them off sharply from 'negroid' peoples further east, though few of the latter have been tested.

In Europe we find the Asiatic combinations of *D*, namely *CDe* and *cDE*, together with the *Rh* negative gene *d* (mostly in the combination *cde*). The proportions of the different subgroups show remarkable constancy over almost the whole of western and central Europe.

Let us however, consider only *D* and *d*. When a woman of genetic make-up *dd* bears a child who is *Dd* (with *d* inherited from the mother and *D* from the father) she will in a small proportion of cases develop an antibody to the *D* substance present in her child's blood, which will in turn destroy its red blood cells and cause it to be born suffering from jaundice and anaemia ('haemolytic disease of the newborn'). Since the children who die of this disease are all genetically *Dd*, equal numbers of *D* and *d* genes are destroyed by this means, and in the course of many generations either *D* or *d*, whichever was the rarer at first, will tend to die out. In non-Europeans *d* is perhaps uniformly rare for this very reason. In Europe about 16 per cent. of people are *dd* from which it may be calculated that in the whole population there are 40 per cent. *d* genes and 60 per cent. *D*. This is, for the reason mentioned, an unstable state of affairs and we may suppose that the present population arose from the interbreeding a few thousand years ago of two great racial groups, one mainly *Rh*-positive or *D*, and the other mainly *Rh*-negative or *d*.

On this hypothesis the *D* element almost certainly came from Asia where the subgroups of *D* are of the right kind, but until recently no candidate for the *d* element could be found, since no population was known with more *d*'s than the general European average. It has recently been found in the Basques who even now have about 30 per cent. of *dd* individuals or nearly 60 per cent. of *d* genes. Probably the modern Basques, though the least mixed people in Europe, have not quite the high *d* frequency of their ancestors, but all their other characteristics are in keeping with the theory that they are the almost pure representatives of a people which, mixing with peoples from the east, gave rise to modern Europeans. We can even feel some certainty in identifing them with one particular race known to prehistorians.

First, as regards their *ABO* blood groups, they have a much lower frequency of group *B* than any other Europeans. *B* is typically an Asiatic group and increases eastward in Europe. Secondly, the Basques are the only people in Western Europe who speak a non-Indo-European language. Thirdly, skeletally they closely resemble Crô-Magnon man, the most important late Palaeolithic inhabitant of western Europe.

Thus it is the Basques who are the most European of Europeans, the one people who have been here since Palaeolithic times and probably still speak the language of our Palaeolithic forbears, while we, the people of the rest of Europe, Arians and Jews, Nordics and Alpines, Celts and Slavs, are all half-breeds, mixtures of east and west—and who shall say that we are any the worse for it?

Haemolytic Disease of the Newborn

by

Dr. P. L. Mollison

Haemolytic disease of the newborn is a comparatively common condition, affecting about 0·5 per cent. of all infants born in Britain. The very special interest of the disease, and the reason for discussing it at this session, lies in the fact that it has been shown to be due to a particular blood-group difference between the parents. In brief, the mechanism is this: the father hands on to the foetus an antigen, *Rh*, which is foreign to the mother; the mother forms antibodies against this antigen and these enter the foetal circulation during pregnancy and cause destruction of the foetal erythrocytes. The infant may be killed *in utero*, but more commonly it is born alive with anaemia and jaundice. After birth the infant is cut off from the supply of damaging antibody, and as a rule it slowly recovers. Some infants are critically ill and these can be helped by blood transfusion, as will be explained later.

The antigen responsible for this process of maternal isoimmunisation is conveniently called *Rh*, although in fact this term covers a number of separate antigens. However, one *Rh* antigen, *D*, is so much more often responsible than the others that the popular term

Rh can be used as equivalent to *D* with little loss of accuracy. In this country about 84 per cent. of the population are *Rh*-positive, and it is only the remaining 16 per cent. of people who can become immunised to *Rh* and form *Rh* antibodies. Thus only 16 per cent. of women are liable to have infants born with haemolytic disease, and some of these are removed from danger by marrying *Rh*-negative husbands. Most of the others will never have an affected infant because immunisation to *Rh* during pregnancy is only an occasional occurrence.

Isoimmunisation to *Rh* only very rarely occurs to a sufficient extent during a first pregnancy to cause haemolytic disease of the newborn. Even when a second *Rh*-positive infant is born to an *Rh*-negative woman, the chance that it will have haemolytic disease is still less than 1 in 10. Indeed, many women fail to become immunised to *Rh* even after repeated pregnancies with *Rh*-positive infants. The chance that an *Rh*-negative woman married to an *Rh*-positive husband will have an infant affected with haemolytic disease is, of course, less if her husband is heterozygous for the *Rh* factor because then, in each pregnancy, there will be an even chance of the infant's being *Rh*-negative.

The fact that pregnancy with an *Rh*-positive infant does not invariably lead to the formation of *Rh* antibody by the *Rh*-negative mother is probably to be explained in two ways. Firstly, it is likely that only very minute amounts of blood leak from the foetus into the mother's circulation during pregnancy, so that pregnancy offers a poor and erratic stimulus compared with the direct intravenous injection of blood from one person to another. The transfusion of *Rh*-positive blood into *Rh*-negative patients has been shown to lead to the formation of *Rh* antibody in practically 50 per cent. of cases, whereas a single pregnancy with an *Rh*-positive infant only causes the formation of *Rh* antibody in about 1 or 2 per cent. of cases. Secondly, there is evidently also a biological difference between different subjects. Experimentally some *Rh*-negative subjects have proved to be extremely resistant to stimulation by *Rh* so that even long courses of intravenous injections of *Rh*-positive blood are not followed by the production of antibody. Doubtless this explains why some *Rh*-negative women give birth to a long series of *Rh*-positive infants without ever forming *Rh* antibodies.

It is of great interest that of the many antigens occurring in human bloods, only *Rh*, with very rare exceptions, causes haemolytic disease of the newborn. Women of Group *O* who bear infants of Group *A* or *B* frequently become immunised to these antigens, but this never, or at most very seldom, causes haemolytic disease of the newborn, although there is some evidence that it may sometimes cause death of the embryo at a very early stage of pregnancy. Later in pregnancy at least, the foetus seems to have an adequate protection against anti-*A* and anti-*B* agglutinins in the mother's serum.

The serological basis of haemolytic disease of the newborn human infant has only been understood since 1941, when Levine and his associates in the U.S.A. first published their evidence. Knowledge of the aetiology has greatly facilitated the management of the condition. For instance, the occurrence of the disease can be predicted by routine testing of pregnant women for the presence of *Rh* antibodies and this has become a standard practice in many ante-natal clinics. Arrangements can be made for women who develop *Rh* antibodies to have their babies in hospitals and this is important because the infant usually requires treatment which cannot easily be given in the home.

A further important advantage of ante-natal testing is that if the woman herself requires a blood transfusion, one knows whether to give *Rh*-positive or *Rh*-negative blood. An *Rh*-negative woman who has formed *Rh* antibodies may be killed by being transfused with *Rh*-positive blood. The transfusion of *Rh*-positive blood to an *Rh*-negative woman who has not formed *Rh* antibody carries no immediate danger, but may later have disastrous consequences. This it may do by sensitising her to *Rh* so that during a subsequent pregnancy the slight additional stimulus, which by itself would have been ineffective, is now sufficient to arouse production of potent *Rh* antibody. There is evidence that an *Rh* negative woman who is transfused with *Rh* positive blood and subsequently gives birth to an *Rh*-positive infant has a 70 per cent. chance of having an infant affected with haemolytic disease. Moreover, under these circumstances the infant is very likely to have the disease in a severe or fatal form. It is evident that many of these infant deaths are preventable, and at the moment every effort is being made to extend facilities for *Rh* testing to all hospitals.

Although it is possible to prevent sensitisation to *Rh* by transfusion, there is at present no known method of preventing a mother from forming *Rh* antibody during pregnancy. Thus there are only two known methods of treating haemolytic diseases: firstly, pregnancy can be determined prematurely to diminish the time for which the infant is exposed to *Rh* antibody; secondly, the infant can be transfused with *Rh*-negative blood. It has been shown that *Rh*-positive erythrocytes are very rapidly broken down in the

circulation of affected infants, whereas *Rh* negative erythrocytes enjoy a long life span so that their transfusion results in a sustained increase in the circulating red cell volume.

A logical further step in treatment is to perform an exchange transfusion as soon as possible after birth, removing the bulk of the infant's own erythrocytes and replacing them by *Rh*-negative ones. This can be done very conveniently by passing a fine plastic catheter up the umbilical vein and then sucking out the infant's blood and replacing it by *Rh*-negative blood in small successive stages. Results with this technique are very encouraging but it is too early to assess the effect on mortality and morbidity. Certainly one should not give the impression that every severely affected infant can be saved by this method. Almost one-third of infants with haemolytic disease still die despite treatment, and it does not seem that much more can be hoped for in view of the fact that some infants are so severely damaged during pregnancy as to be born dead. It seems that only the discovery of some method of preventing *Rh*-negative women from forming *Rh* antibody or for neutralising the antibody when formed will provide a really satisfactory form of treatment.

It is hopeful that there is at least the possibility of studying the disease in animals. Caroli and Bessis have shown that newborn mules sometimes suffer from a condition very similar to haemolytic disease of the newborn human infant. During pregnancy the mare forms antibodies against an antigen present in the erythrocytes of the mule and inherited from its sire, the donkey ; it is evidently these antibodies which cause the rapid destruction of the mule's erythrocytes after birth. More recently Coombs, in association with veterinary colleagues at Cambridge, has shown that there is a very similar condition in newborn thoroughbred foals. With his co-workers Dr. Coombs is at present trying to produce the disease in rabbits, and he has reported that his early results have been more than promising.

Should it prove possible to produce the disease in animals at will, work on the fundamental aspects of haemolytic disease will be very much easier. Meanwhile, many lives can be saved by the widespread application of knowledge already gained from a study of the disease in man.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE American Association was founded in 1848 and Centenary Celebrations were held in Washington from September 13 to September 17, when the theme of the meeting was ' One World of Science.' The following is the text of an address of congratulation from the British Association which was presented to the President of the American Association by Sir Oliver Franks, British Ambassador to the United States.

To all the members of the American Association for the Advancement of Science from all the members of the British Association for the Advancement of Science, fraternal greetings and warmest congratulations on the attainment of the hundredth anniversary of your Association.

We are proud of the fact that the British Association, founded in 1831, served, to some extent, as a model for the American Association and that it has been possible for our two Associations to work in close harmony during the past century.

As you halt at this turning point to assess the achievements of a long journey and to survey the prospects on a road that knows no ending, we assure you of our continued interest and co-operation in all that you undertake for the achievement of our common aims and high purposes.

We have seen your Association grow steadily into an organisation of over 33,000 members, with an affiliated membership of more than half a million men and women, and your annual meetings become the largest general assemblies of scientists in the world.

We have also watched with admiration and respect your growth not only in numbers but in strength and in influence which, without serious interruption by the Civil War and two world wars, have made such substantial contributions to the advancement of science and its applications to human progress.

With congratulations on the solid achievements of the past hundred years, we send cordial good wishes for the success of all the responsible work that lies in the future and trust that your second century may begin with a brilliantly successful week of celebration and discussion.

During the past half century there have come about changes in the conditions of life more far reaching than any others in human history. Distance has been virtually annihilated and all men have become neighbours. But men are not yet neighbours in spirit as well as truth and the universal status of science, which is its proudest claim, is also its greatest opportunity. In an age which is characterised by perfection of means and confusion of ideals, science and the discipline of science, which admit no frontiers of race or creed, provide a basis for effective international co-operation in promoting the welfare of mankind.

May it not be too much to expect that there may go forth from so great a gathering of men of science in Washington a new message of hope to a troubled world.

H. T. TIZARD, *President.*
EDWARD F. HINDLE,
R. V. SOUTHWELL,
General Secretaries.

CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES

BRIGHTON MEETING, 1948

In accordance with the arrangements made by the Corresponding Societies' Committee, the Conference of Delegates during the Annual Meeting of the Association at Brighton was held in two sessions, the first, on Thursday, September 9, in the Royal Pavilion, when Professor H. J. Fleure delivered his presidential address, which was followed by discussion, and the second on Monday, September 13, when delegates attended a conversazione. The following is a report of the proceedings.

First Session : Thursday, September 9, 1948.

THE CORRESPONDING SOCIETIES AND THE COMMUNITIES THEY SERVE

ADDRESS BY

PROF. H. J. FLEURE, F.R.S.

PRESIDENT OF THE CONFERENCE

THE BRITISH ASSOCIATION works for the advancement of science especially by providing a forum for discussion of broader aspects of scientific research and by publicising work which might otherwise get insufficient attention. It gathers together in this conference the delegates of a great number, and variety, of societies which in diverse fields work towards the same ideals. Many of these societies belong to various towns or counties and it is with ways in which the Association can, I think, help such societies that I want to deal. I have felt my duty to be in this direction because it seems to me that developments in education and social life are giving increased opportunities to those societies and, in co-operation with them, to the British Association.

Man is a social being and he has for long ages been primarily a number of a small and local group. Rousseau, with all his thoughtfulness, yet led people astray when he pictured the noble savage bartering his individual freedom for social advantages. And Hobbes also led people astray when he pictured society as taming the primal brutish individual. The error in both is the implication that the individual came first, that individuals have met together to create a social group. With a few special exceptions such as hermits and outcasts, all men live in groups ; and I think we may go so far as to suggest that they seem to have done so from the beginnings of humanity, indeed in all probability from a long pre-human phase. The dependence of the reproductive cells on the parent has often been indicated as a germ of social life.

The group-regarding habits have conflicted with and attempted reconciliations with the self-regarding habits throughout all that part of the life of mankind of which we have relevant evidence. In this conflict and search after reconciliation, the group has again and again sought to impose uniformity, or what the new masters of Czechoslovakia call unanimity, on all its members. It has repeatedly said, 'We are right. We have the truth' and has used its power to persecute dissentients, who have been almost as persistent a feature of society as the persecutors. But 'The Wind bloweth where it listeth' and even cruel ecclesiastical policies pursued through centuries could not extinguish the Inner Light. Individuality is the fine flower of the social garden that no weeds can choke for ever. In the sixteenth and seventeenth centuries of our era the work of Copernicus, Galileo, Huyghens and Newton brought into human ken the idea of the immensity of space, of the untold numbers of heavenly bodies among which our solar system is but a small item, with our earth a minor element in it. We need only read anything of the literature relating to man and the universe written before Copernicus to realise how fundamentally the advancement of science, by observation and analysis, changed man's outlook more and more as time went on. In place of the old claim of the social group 'We have the truth', there grew up the deeper rooted reverence expressed in 'We seek the truth'. Gradually repression by the social group of the individual's thought weakened, and advances towards freedom of conscience began. Our Royal Society, devoted to the increase of

natural knowledge, had its embryonic years during the Civil War and the Protectorate, and received its charter in 1662; and parallel movements in other countries occurred just before or just after this. In the eighteenth century more societies of this kind came into existence, and, in one famous case, I have noticed what a large part was played by men who were dissentients from then currently received, that is from group, opinions. But these movements were in a sense eclectic, they affected only, or almost solely, their own adepts.

In the late eighteenth century there burst upon Britain, and thence upon the world, the miracle of steam-power and of mass production. The ship of society was made to sail on an uncharted sea under a series of captains who found philosophers to justify their adventures under the name of Laissez Faire. The age-old desire for power now sought its opportunity not by conformity but by initiative; and, if persecution was less than under older systems, oppression of the less fortunate remained almost as serious as before. What was equally dangerous was the changing of the little old social groups that we call villages and old towns into crowds; and the casual nature of a crowd gives a motive power vastly different from that of a social group, too often fear and hatred in place of constructive co-operation. Old groups began to lose their vitality, there remained little grouping between the individual family on the one hand and the whole nation on the other save and except voluntary societies and efforts to maintain loyalty to city or county. Individualism went very far; and, in our day, we are witnessing many fierce reactions against it. As I see the situation, the methods of securing uniformity in mediaeval Europe are being copied by totalitarian régimes in many lands. Freedom of conscience is attacked and repressed by Right or by Left Terrors in different cases. We have seen the decline of the search for truth in the Germany of 1933–1945; the springs of thought were fouled. There are distressing signs of the same fouling under the other dictators. It is for us to open, to keep open, the crystal fountain for the healing of the nations, remembering that freedom of conscience in research and expression does not carry with it freedom of exploitation of the weak, in other words that the social group matters fundamentally and must re-emerge where it has been swamped by the crowd.

All this I know has links with vast questions of social and political and religious life with which we do not deal here. But it has bearings on our work that I must try to set forth.

Our social feelings are intimately concerned, and traditionally concerned, with small local groups. The life of these groups, past, and I hope present and future, needs to be fostered and broadened and brought into the main streams of thought, without being drowned in them. And this is one of the major tasks of our local societies. Speaking as one who has the antiquarian feeling, I would plead that, along with the study of the past, and sometimes along with efforts at restoration of gracious features obscured in the industrial revolution, we should get our local societies, which have so much historical and archaeological interest, to concern themselves with the views of the planners who are now showing so much zeal. The planners need the antiquary's restraining hand at times, and his guidance always, provided that he does not think everything old must be preserved at whatever cost just because it is old.

The local society has its difficulties; it has often found that any major contribution to knowledge even from its own locality goes rather to a national society and its journal than to the local society, in the transactions of which it might be lost for many years, as was the famous study of peas by Gregor Mendel. But the Victoria County Histories and the volumes of the Royal Commission on Ancient Monuments and other great series publish much that might occupy local societies, and their members have made massive contributions to such works.

A secretary of a local society recently told me that practically all his members had joined in visits to all the points of interest within the society's acknowledged territory, and he wondered whether the society should shut down.

These are well-known difficulties, but I am sure a lot remains to be explored and discussed, and we look forward to the studies of the counties as discussed in the Domesday Book, studies in which Professor Darby is a leader. We already have the series of Land Utilization Surveys into which Professor Dudley Stamp has thrown so much energy. Those surveys were done in the thirties; it is highly probable that a new set should be undertaken soon.

I think that a consequence of the Education Act of 1944 opens up further possibilities. That Act brought into existence, for the great majority of young people, what are called Modern Schools, to distinguish them from the Grammar Schools supposed to meet the needs of the more academically minded. They are encouraged to work where possible by visual methods, including the practical study of the life of their own locality, which has already been so profitably developed by

many grammar schools. This is the work that Sir Patrick Geddes advocated and called Regional Survey. I well remember his special request to me shortly before his last illness to help the Le Play Society, which he named after the French observational sociologist, and which he hoped would develop this line of study. The Geographical Association and its branches, and the Historical Association too, and now the establishments of the Council for Field Studies, are all at work in this direction. For the purpose of helping the teachers and pupils of our modern schools there is need of books on our districts and towns that shall give vital pictures of human life and its evolution in each locality, and the preparation of such books is a field of invaluable public work for local societies on Regional Survey lines. Don't let us try to plan a uniform series ; don't let us enforce the county as a unit, or the 1-inch sheet of the O.S. map either. It is not uniformity, it is rather vitality that is needed. Different groups will find diverse lines of approach, and all one would suggest here is that, whenever possible, members of local societies should be invited into the schools to talk about the district, and that teachers should be welcomed by the local societies and helped to gain the requisite knowledge if they have not yet got it. The British Association might contribute much by forming a committee to give help, or to find help, on special points, and, generally, to promote the issue of books or booklets such as have been hinted at above. If we can get a movement going which shall cover the whole country in the course of time, we shall be serving education, and promoting the social vitality of towns and rural districts of our countries. The British Association can help to prevent dangers of narrow parochialism inherent in work of this kind.

I think the British Association could give further help in this direction. The local societies often long for a stimulus from outside, a stimulus that is not always given by a lecturer visiting the society for one evening's public lecture. Some local societies are in cities which can, twice or three times in a century, welcome the British Association as a whole. But a number of smaller cities and towns lack the accommodation and cannot provide the large membership necessary to avoid an impossible drain on the Association's Funds. Could the Council or a Committee of the Association receive and consider applications to furnish a suitable but not very large number of delegates for a meeting in some district, town or city ? The delegation would be chosen with a view to special interests and opportunities in the place of meeting, but would I hope include at least one expositor of current progress in some branch of science of wide public interest. How far such an arrangement should be related to the Division for the Social and International Relations of Science would, I think, be for the Association to consider ; and, if the idea is taken up, I hope an exploratory committee may be appointed. How many such meetings could be held in a year would depend upon funds and staff available, but one can think of such places as Exeter, Gloucester, Shrewsbury, Carlisle, Lincoln, Northampton, Middlesbrough, Perth, Inverness, Bangor, Aberystwyth and many more getting help and encouragement by contact with main streams of scientific thought and also of the refreshment of local studies by the introduction of new questions and new points of view. The effort could be a part of what must be a general task, that of revivification of our local community. I should hope that, as a follow-on from such meetings, local education authorities would develop week-end and vacation courses, especially for teachers in their modern schools, and would see that at such courses the free breezes of science do impinge upon the teachers' minds and stimulate them to do individual work. If the modern school is not to fail, it must have many teachers who will work because of an inner urge within themselves. Education at its best is a fertilising contact of personalities, and this is peculiarly needed for schools in which the pupils are, for the most part, not inclined to pore over books.

The British Association, the local society, the schools if they work along these lines, can help to place on record and, where possible, make hand models of implements and objects of many kinds ; I have seen such a collection of small models of traditional rural vehicles in Northern Ireland, where studies of this kind have been considerably developed in connection with Queen's University, the Museum, and the Belfast Naturalists ; and one might mention specially the late Mr. Welch, as well as some living researchers among whom the veteran Dr. Praeger's name has a high place. The Royal Anthropological Institute has a committee trying to explore ways and means for promoting such studies ; and a recent exhibition by Mr. Salaman at St. Albans has been a helpful supplement to the great work on traditional material culture carried on by several modern museums. York, Salisbury, Norwich, Cardiff, Luton, Wisbech, Hereford, Tickenhill, Cambridge, Lewes, Keighley are examples. Such museums, with many diversities, should be developed all over the country and replace what are too often dead collections, the details of which are all too familiar. The local museum needs help and appreciation,

and I hope the meetings to which the British Association might send delegates would give great encouragement.

It is my belief that a vivified local museum with a local society encouraged by contact with the general body of scientific thought through the British Association could be a great help towards the enrichment of local citizenship. Citizenship on a high level is more than ever needed in these days of planning. Plans may be good, if they take into account enough of the vital factors involved ; they may be evil if they forget essentials and carry through changes that amputate the diversities within the community and try to impose uniformity.

The Literary and Philosophical Society of Manchester was founded by a group that had, some years previously, come under the influence of Joseph Priestley. They took up many subjects of discussion and the numbers struggled for educational and sanitary and other reforms ; they were essentially a fount of diversity, or, if you will, of dissent from generally received opinion. Their efforts provided an opportunity for John Dalton to become a man of science and James Prescott Joule also owed the Society a good deal and repaid that debt by devotion to its interests. As one of the planners of the time was Robert Owen, we may surmise that his membership of the society may have exercised some influence on his thought. I want to emphasise over and over again that thoughtful diversity is one of the most precious features of social life, and planners who may favour it are nevertheless in danger of preparing the way for its repression. One feels deeply conscious of the dangers attached to schemes discussed at a recent Scientific Information Conference of schemes which aimed at tidier organisation and economy but would have opened the gates to political repression. One of the advocates of these schemes looked forward to a connection between a central authority distributing scientific papers to societies and the government grant for scientific publication administered by the Royal Society. We need only think of the treatment of the work of Einstein in Germany and of that of Vavilov in U.S.S.R. to realise the dangers involved. It has been the spirit that made voluntary societies which has given British life its characteristic resilience. Voltaire's jest about England as the country of a hundred religions and one sauce was a tribute we should cherish.

In the course of this talk I have mentioned studies of our traditional local implements, vehicles and other items of material culture. We need to make a further effort, with and through local societies to develop more and better local museums as I have suggested, to contribute to efforts of the Royal Anthropological Institute and the Folk-Lore Society to place relevant facts on record, and at the same time, to widen the contacts of local societies in every possible way. One society, the Cambrian Archaeological Association, has held its annual conference, from time to time, in places outside Wales: Cornwall, Brittany, the Isle of Man, Ireland have all been visited. If the British Association can appoint a Committee to help local societies in the ways suggested above, that committee might do much to help exchange visits between local societies. That Committee might also secure help from local societies in the preparation of our National Atlas, which I should like to envisage not as a ' once for all ' publication but rather as an institution that would remain active and produce a stream of maps based on research. The freedom of the local community from central dictation and its strengthening by expert help are ideals for which this Conference can and will work.

[Sir John Myres sent Professor Fleure the following letter of support, coupled with regret that he could not be present :—

' You have touched the fundamental issue of voluntary social and local co-operation : what I am inclined to call the " congregational " outlook, which has so long and wide a history, and is so deep rooted in our own culture. The local society is the natural complement to the local museum and library, a social centre for all intellectual and aesthetic interests : it is the modern equivalent, and heir, of the old Mutual Improvement Societies and has a long suggestive history.

' Only in a few cities, such as Leicester, and, as you hint, in the Literary and Philosophical Society of Manchester (you might add Leeds and Liverpool as other early examples) has this type of institution fully flourished ; and, wherever it has flourished, it has done immense social service. What the British Association can do, and has it in its tradition to do, is to connect these local institutions with the great specialist research societies. This is why it moves year by year from place to place with its flood of information and inspiration. And the Conference of Delegates of Corresponding Societies is the Association's proper point of contact with each district and group.']

Discussion on the address brought into prominence some of the methods adopted by societies to stimulate membership and interest. These showed that the curators of local museums and masters and mistresses in the schools were interesting young people in the natural history of their districts. Some scheme of junior membership of the local societies for youths and for the senior pupils

of neighbouring schools was advocated and, indeed, had been found successful in some of the Corresponding Societies.

Much support was expressed for the institution by the British Association of a panel of lecturers, who could speak with authority in their special branches of science, and who were willing to visit the Corresponding Societies. It was suggested that the lectures might be arranged in association with visits to appropriate places during selected week-ends. Natural science and archaeological lectures need not be the only types to be considered, for other interests might be equally absorbing. Indeed every section of the Association could play a part in different regions.

The question of expense was debated, and it was thought that members of the particular Corresponding Society could be found who would give accommodation to visiting lecturers, so that travelling expenses and a fee of say £2 2*s*. would be the only cost to the Society. It was thought that the Corresponding Societies' Committee might explore the possibility of giving assistance to such Corresponding Societies as might wish to avail themselves of such an opportunity. But it was to be understood that such a scheme must not interfere with the normal programme of the Society's activities. These lectures must be of the nature of special occasional events.

Dealing with other matters it was reported that the resolution sent forward from last year's meeting at Dundee asking that important papers communicated to local Societies should be reprinted by the Association had been referred to the Council's Publications Advisory Committee, and it was thought that, for the time being, the cost would be prohibitive.

A further suggestion that the Association might publish critiques of papers published by Corresponding Societies was also discussed. While recognising that such digests would be most helpful, it was reported that authors sometimes protested that fair representation of their work was not always given. Such objection could be met by publishing authors' abstracts.

But there appeared to be another method of ensuring that local works, particularly those containing local natural history records, might be made more widely known. District unions of local Societies might be strong enough financially to publish joint proceedings embodying these records. There would be great advantages in such a scheme, because local workers would have their records adequately published, and those desiring to use such local details would have much less trouble in obtaining the details they required since these would be concentrated in a few journals appearing regularly and at frequent intervals.

Second Session: Monday, September 13, 1948.

The second meeting was held in the Art Gallery and Museum, where the main gallery was placed at the disposal of the Conference for the afternoon. A conversazione had been suggested for this occasion in order that the delegates might meet less formally and be able to exchange their views in a more personal manner. Small exhibits were therefore sought from the local Corresponding Societies, and the response was encouraging. The underlying plan was that societies whose members had special interests might have the opportunity of preparing exhibits, talking about them for a few minutes and using them as a means of obtaining the views of other delegates. In the end there was no opportunity for short talks on the subjects of the exhibits, but the main object of the plan was achieved. The exhibits included illustrations of aerial photographs as applied to scientific research in archaeology, agriculture, military observations and other interests. The palaeontology of the local rocks—the chalk and the tertiary strata—was illustrated by two further exhibits, while archaeology was also represented by (1) a suite of stone implements; and (2) mammalian remains from a recently discovered cave near Torquay. Those of a less local character included astronomical photographs and special engineering tools. It was evident that the plan could be extended over a wide field, if desired, or restricted to a narrower one, if the special interests of some section were considered to be appropriate at any special meeting of the Association. The response to the appeal for exhibits was not all that might have been expected, however, although the character of the meeting certainly gave delegates the opportunity for the more intimate discussion that had been desired. Other methods of attaining this end might be devised and tried out at future meetings.

Tea was served during the afternoon and the introduction of the more social atmosphere at the meeting seemed to be appreciated. The principal officers of the Association were able to use the occasion for meeting the delegates from Corresponding Societies individually, and so learning at first hand their views on the relationship of the Association to local Societies.

Representation at the Conference.

Delegates to the Brighton Meeting were appointed by the following Corresponding Societies :

Ashmolean Natural History Society of Oxfordshire.
Association of Women Science Teachers.
Blackburn Philosophical and Scientific Society.
Brighton and Hove Natural History Society.
British Optical Association.
Cardiff Naturalists' Society.
Devonshire Association.
Dumfriesshire and Galloway Natural History and Archaeological Society.
English Folk Dance and Song Society.
Folkestone Natural History Society.
Folk-Lore Society.
Geographical Association.
Geologists' Association.
Geological Society of Edinburgh.
Glasgow and Andersonian Natural History and Microscopical Society.
Hampstead Scientific Society.
Hastings Natural History Society.
Hertfordshire Natural History Society and Field Club.
Isle of Man Natural History and Antiquarian Society.
Le Play Society.
Liverpool Geological Society.
National Association of Head Teachers.
National Farmers' Union.
National Trust.
National Veterinary Medical Association.
Natural History Society of Northumberland, Durham and Newcastle-upon-Tyne.
New Europe Group.
Northern Naturalists' Union.
Plymouth Institution.
Portsmouth and District Chemical Society.
Purley Natural History Society.
Rochester Natural History Society.
Royal Entomological Society.
School Nature Study Union.
Society for the Promotion of Nature Reserves.
Sorby Natural History Society.
South Eastern Union of Scientific Societies.
South London Entomological and Natural History Society.
Southport Scientific Society..
Teign Naturalists' Field Club.
Worthing Archaeological Society.
Yorkshire Geological Society.
Yorkshire Naturalists' Union.

WORLD FAT SUPPLIES IN RELATION TO THE NEEDS OF GREAT BRITAIN AND THE COMMONWEALTH[1]

BY

PROF. T. P. HILDITCH, F.R.S.

IT is desired in this paper to direct attention to a few of the more important factors which affect the development of a steady and sufficient production of fats, especially those necessary for consumption in Great Britain and the Commonwealth—either in food or for use in the detergent, paint and some other industries. To this end the prospects of increasing world supplies of fats will be considered on general rather than on specific lines, whilst reference to statistics—sometimes not easy to obtain with accuracy, and often liable to be somewhat misleading—will be confined as far as possible to such data as are indispensable to the argument. It is necessary nevertheless to define the problem in general numerical terms at the outset in order to set it in proper perspective.

Taking Great Britain alone, it has been said that the pre-war consumption of fats supplied as such for edible purposes was at the average rate of about 40 lb. per head per annum, or about 12 ounces per person per week, equivalent to the provision of about 800,000 tons per year of fats for use as butter, margarine or cooking fats. As will be seen in a few moments, these figures do not cover the total intake per person of dietary fat, but only that supplied in the form of fats produced as such—quite a different matter. At the moment, however, let us try to form an

[1] Paper read before Section B (Chemistry) and Section M (Agriculture) at Brighton on September 9, 1948.

estimate of the total quantity of fats required to put this country into a comfortable position. From what has just been said it follows that we could very well absorb 1,000,000 tons of fats yearly for edible purposes alone ; for the production of soaps a further 300,000 tons of fats are required to maintain the pre-war standards, and for other uses (chiefly those of the paint and varnish industries and those manufacturing linoleum and some other fabrics, including leather) another 200,000–250,000 tons of fatty oils are necessary. Therefore, as a rough basis, we may say that this country needs annual supplies of fats and fatty oils of at least 1,500,000 tons, and that of this quantity about two-thirds is needed for human consumption as edible fats, whilst about 20 per cent. of it could be used in soaps and related detergent products and about 15 per cent. of it is required to supply the paint, varnish, linoleum and similar industries.

Edible Fat Supplies in relation to Total Intake of Fat by the Population

Since supplies of fats for edible purposes form so high a proportion of the total fat requirements of the country, and since shortage of dietary fat is naturally that which forces itself most insistently upon the notice of the community, it is well to consider carefully some aspects of the total sources of nutritional fats before surveying the problem of increased supplies of fats of all kinds to Great Britain. It is obvious, as already mentioned above, that the average consumption of edible fats supplied as such—about 12 ounces per head per week or rather more in 1938, and 7 (or formerly 8) ounces on our present rations—is only part of the story. Quite a significant proportion of human fat intake is derived, not from fats purchased as such, but from other fat-containing foods such as milk, eggs, bacon, beef, and so on. It is interesting to read in this connection an article on ' The role of fat in human nutrition' by the American nutritionist H. J. Deuel (*Oil and Soap*, 1946, **23**, 209), where it is stated that the average fat intake per person in the U.S.A. before the war was 125 gms. per day (31 ounces per week), whilst that of the American soldier during the war was 193 gms. per day (44 ounces per week). This of course refers to total fat intake, and not merely to fats purchased as such. Whilst, however, the pre-war *per capita* consumption of fat in the U.S.A. was no doubt greater than in Britain the important point to observe is that the quantity of fat taken through foods such as milk, eggs, meat, etc., undoubtedly has fallen off in this country proportionately more than that of the actual purchased fat. The present-day purchased fat ration probably represents more than half but less than two-thirds of the pre-war consumption of purchased fat, but the decline in the ' invisible ' fat intake in the form of other foods is clearly much more serious.

Thus, the recent winter ration of 2 pints of milk per week per person should involve the consumption of about 1½ ounces of milk fat, but a pint of milk per day would supply the same person with over 5½ ounces of milk fat. So that, considering only the case of milk, the total fat intake of a person on the 7 ounces per week purchased fat ration would be 8½ ounces on the one hand, and 12½ ounces on the other. Similarly, the yolk of the hen's egg contains about one-third of its weight of fat, which amounts on an average to about 5 gms. An ' allocation ' of one egg per week makes little difference to the total fat intake, but an egg per day would afford an additional 1¾ ounces of excellent dietary fat per week. The matter is less easy to illustrate numerically, but is as serious if not more so, in the cases of meat and bacon. Here it is not only restriction of the quantity purchasable, but it must be common knowledge that these commodities are frequently far less rich in fat than before the war. It may be argued that not every one cares for very fat beef or bacon, but no efficient housewife ever wasted the excess fat from either source, knowing its value, if not for cooking purposes, at least as ' dripping.'

I have given some little space to this point because I believe it is of considerable importance. Increase in the supply of these so-called ' invisible ' fats will not solve the problem of increasing supplies of imported fats or oilseeds, but it would have a beneficial effect upon the consumer beyond the apparent quantitative increment of the fats derived from such fatty foods. People on the whole have become acutely fat-conscious. They may well have forgotten, or have decided in the light of personal experience to ignore, authoritative statements made early in the war period that fats after all did not matter much, so long as there was starch or carrots to eat. They have probably lost interest to some extent in calories and vitamins, but they are conscious of a lack of fat in the diet, and they visualise this in terms of the fat ration, i.e., fat purchasable as such. Is it not time to admit equally authoritatively that the slaughter of pigs and poultry early in the war, and the cutting-down of cattle and poultry feeding-stuffs, were either most deplorable necessities or errors of the first magnitude ? However this may be, I hope I have made it clear that more than one-third of the real lack of dietary fats ought to be made up from commodities such as milk and meat, and it seems only right that this feature should

receive due consideration in a paper addressed to the Agricultural Section of the British Association.

Sources of Fat Supplies

These fall of course into three divisions : animal fats (including butter), marine animal oils, and fats and fatty oils from vegetable fruits and seeds. Some idea of the fluctuations in supplies so far as Great Britain is concerned, may be obtained from the following table which shows the imports of butter, and of various other fats into the United Kingdom for a pre-war year, during the war, and in 1945, 1946 and 1947.

Import of Fats into the United Kingdom

(Thousands of Tons)

	1938	1942–44 (Average)	1945	1946	1947
Butter	476	150	190	211	216
Tallow	24	28	21	12	23
Lard	72	210	90	36	16
Whale Oil	225	45	46	67	145
Fish Oils	21	49	19	22	22
Fats from Oil-seeds	785	826	572	633	790
Total	1,603	1,308	938	981	1,212

More detailed statistics will be found in an informative article by the late F. A. Fehr (' Present world position of the supply and demand for oils and oilseeds,' *Bull. Imp. Inst.*, 1946, **44**, 183). Here the following additional notes may suffice.

Animal fats.—Butter was imported to the extent of nearly 500,000 tons yearly before the war. Imports fell to a minimum in 1942 (134,000 tons) but have since risen to about 200,000 tons. Home production of butter probably amounts to about 10 per cent. of the quantity imported. Imports from Australia and New Zealand, Eire and perhaps Denmark, should increase again as time goes on, but have a long way to go to reach the pre-war quantities. The other animal fats to be considered are suet or tallow from oxen and sheep, and lard from pigs. Nearly all the imported lard, and about 80 per cent. of the imported tallow, came from the American continent, and chiefly from the United States. Consequently currency factors, and also the increasing needs of the U.S. population, introduce complications here as regards supplies to this country. The figures for lard given in the table are interesting from this point of view : with the aid of ' lease-lend ' the pre-war imports were trebled during the later years of the war, but fell off in 1945 and still more in 1946 owing to its termination. Production of lard and tallow is of course a function of the number of pigs, cattle and sheep raised, and the total quantity available, at all events for export, in the next few years is not likely to exceed the pre-war amount; moreover, with the exception of some tallows from Australia, much of the beef tallow comes from the United States and the Argentine, and practically all the lard from North America.

Marine animal oils.—Whale oil and certain fish oils are very suitable, after hydrogenation, for margarine and cooking fats. The pre-war catches of whale oil were annually of the order of 450,000 tons, but it is very doubtful whether this was not excessive, and involved killing the whales at a rate faster than they are reproduced. After low production during the war, whale oil has now recovered to an annual catch of perhaps 250,000 tons. Since a yearly production of 300,000–350,000 tons is perhaps the maximum consistent with non-depletion of the whale population, and since this quantity has to meet the needs of other countries besides our own, the limits of supplies of whale oil to this country seem to be in the region of 120,000 to 150,000 tons per year.

The flesh oils of some fish can, however, be used as well as whale oil. This applies notably to flesh oils of the herring family. Herring oil produced in Iceland factories was indeed introduced to this country in Great Britain on a large scale during the war. For many years the establishment of a co-ordinated herring oil and fish meal industry in this country has been mooted, but little has yet been achieved. It has been left to Iceland to demonstrate what can be done. There are admittedly difficulties in the present customs of the British fishing industry and in the seasonal character of the catch, but considerable increase in fatty oil production from fish in the seas surrounding or not too far from these islands could be achieved if a sustained effort on the necessary scale were undertaken. The fatty oil so produced would be a useful addition to our fat supplies, and the fish meal concurrently obtained has of course its own uses in agriculture and in poultry feeding.

Fats and fatty oils from vegetable fruits and seeds.—The vegetable kingdom nevertheless remains the chief field for development of fat supplies, in spite of the circumstance that, as shown in the table, this is a sector in which a very serious decline in imports took place in 1945—a drop of over 200,000 tons on the previous quantities of about 800,000 tons per annum. The reasons for this decline are largely owing to a number of special circumstances, but since the consumption of fats is increasing everywhere it is necessary to consider carefully not only how the leeway may be made up, but also how far production

from these sources can be fostered and increased. In the first place it may be well to review certain features connected with the earlier development of the oil-seed industries.

General Conditions of Vegetable Fat Production Hitherto

The vegetable fat and oil-seed crushing industries, which we thus see to be the present dominating factor in world fat supplies, have developed in the form we know them to-day only within the past sixty years or so. To a large extent they have hitherto depended on produce collected by natives from uncultivated (wild), or only primitively cultivated, species in various tropical regions. This statement applies especially to palm oil, palm kernels, coconuts, groundnuts and a number of other oil seeds. Systematic cultivation of oil-bearing species primarily for their fats is a comparatively recent development, confined largely to the coconut and the oil palm. In the latter instance, the quantity of plantation palm oil and palm kernels produced even just before the war was but a small fraction (at most 15–20 per cent.) of that obtained by native collection. Exceptions to this somewhat sweeping statement are linseed, rape-seed, sunflower seed and a few other annual crops. Linseed was cultivated for oil chiefly in Baltic and Danubian countries, India, and the Argentine ; rape-seed in the same parts of Europe and in India ; the others made no large contribution to fat supplies.

There are, however, some other important fatty oils which have long been produced by large-scale cultivation, but in these cases the seed fat is, from the technical standpoint, a by-product, since the primary objective of the cultivation has been some other product. The oldest and most striking example is perhaps the cotton plant, grown of course primarily for the seed fibres. At the same time, however, United States cotton-seed furnished for many years nearly 1,000,000 tons annually of cotton-seed oil, and this oil when refined was of consistently excellent quality, due to the systematic cultivation of the cotton plant from selected strains of seed. More recently, in the United States, the large development of the soya bean, which is much favoured by the American farmer as cattle food, has brought soya bean oil into much prominence. The U.S. production of this oil has now exceeded that of cotton-seed oil, although the soya bean only contains 20–22 per cent. of oil as compared with about 40 per cent. in cotton-seed. American maize oil is a similar instance of large production of a fatty oil essentially as a by-product of seed grown primarily for other purposes.

The Americans have not been slow to appreciate that fat production, as shown by their experience with the seeds mentioned, is an agricultural problem which, like any other, requires intensive study in regard to the produce to be grown. In the past decade, especially, they have undertaken on comprehensive scientific lines the cultivation of a number of fat-bearing species, including groundnuts, tung trees, linseed and several others. Similar efforts are proceeding in Canada and in Argentina. Any increased fat supplies from these sources in the United States and Canada will be largely if not wholly absorbed in those countries, whilst recent experience of the prices expected for Argentine products should be chiefly valuable in stimulating Great Britain to developing oil-seed cultivation for herself in such suitable areas of the tropics and sub-tropics as still remain at her disposal. I have referred to the recent developments in America, therefore, largely by way of illustration of the manner in which oil-seed cultivation should be promoted.

General Conditions Necessary for Large-Scale Cultivation of Oil-seeds

Obviously the specific conditions for optimum growth of oil-bearing crops require skilled agricultural investigation and control just as much as any other crop, e.g., cereals, roots or—perhaps a better analogy—fruit crops. Variety of seed, soil, temperature and humidity, pest control whether insect or fungoidal, and so on, all require careful study and oversight. As in any other branch of agriculture the co-operation of several sciences is indispensable to maximum productivity. Whereas, however, in any other branch of agriculture all this effort is directed to one end, the quality of the final produce—wheat, swedes or whatever it may be—there has persisted in some quarters a somewhat naïve tendency to overlook in some degree the particular nature of the specific fat produced by a given oil-seed, a tendency, as it were, to regard all fats or fatty oils as much the same thing and, anyhow, just greasy fats. This is perhaps a lingering relic of the old haphazard reliance on native produce and the one-time lack of appreciation in some technical circles of the individuality in chemical constitution of one seed fat as compared with another, and still more of the fact that in some instances of annual crops varying conditions of soil or climate may cause considerable variations, in fruits of the same species, or even variety, of plant, in the proportions of the fatty acids which, combined with glycerol, make up the seed fat.

Of still more importance is the circumstance that in a mature seed the enzymes are

still present and, under suitable conditions of humidity, induce retrogressive changes. The neutral fat in the seed may very readily be partly reconverted into free fatty acids. Special attention to this aspect is essential during harvesting, drying and storage and transport of oil seeds. The beneficial effect of skilled control during gathering the oil crops upon the quality of the fat obtained is strikingly apparent in the case of palm oil, the fat from the flesh of the oil-palm fruit, which is for obvious reasons even more accessible to enzyme attack than an endosperm or embryo fat. The older types of ' native ' palm oil contained up to 30 per cent. of free fatty acid and rarely less than 7–8 per cent. The first plantation oils had about 5 per cent. of free fatty acid, but attention to prompt ' sterilisation ' of the fruit-pulp and rapid methods of separating the fat reduced this to about 3 per cent. Recent trials in the Belgian Congo (Vanneck, *Bull. Agric. Congo belg.*, 1947, **37**, 75) have indicated the feasibility of reducing the free-acidity of palm oil to well below 1 per cent.

Again, ' native ' groundnuts from certain parts of West Africa, owing to lack of proper transport facilities, take an unduly long time to reach the port of export to Europe and are often exposed to unfavourable conditions during this period, and the resulting groundnut oil may contain as much as 10 per cent. of free fatty acid. Other West African groundnuts yield oil with less free fatty acid, but rarely reach the standard of the Indian crop, which used to yield oil (when extracted on arrival in Europe) with only about 3 per cent. of free fatty acid. It is reasonable to expect that, under up-to-date conditions of gathering and storage, the free acidity of the extracted groundnut oil should not exceed 1 per cent. When it is remembered that the yield of refined fat from a crude oil with 10 per cent. of free acid is not more than 70 per cent., whilst that from a crude oil with 3 per cent. free fatty acid is about 90 per cent. and that from a crude oil with less than 1 per cent of free acid is about 98 per cent., the advantage of extreme care in harvesting an oil-seed crop exactly at maturity, and in its drying and in storing, is self-evident.

With most oil-seeds it is sufficient thoroughly to dry the freshly harvested seed and to store it, prior to reaching the oil-mills, under dry conditions and free from infection by moulds or other fungi. Oil-seeds of some species are so rich in lipolytic enzymes, however, that it is well to expose them for a short time to a temperature of about 80–90° C., when the enzymes are completely inactivated and all tendency to development of free fatty acid ceases.

This brief survey of the special problems which arise in oil-seed agriculture may, it is hoped, help to clarify the discussion of prospective oil-seed production in the British Commonwealth with which I should like to conclude this address.

The Prospects of Increased Oil-seed Production in the British Commonwealth

The problem of fat supplies from oil-seeds falls into two divisions, namely, fats for the edible trade and the lesser, but still large, demand for fatty oils specifically useful to the paint industries. For edible purposes there is already a fairly wide range of suitable seed fats the compositions of which are fully known and it is therefore a matter of selecting a comparatively small number for intensive cultivation, embracing several types of solid, semi-solid and liquid fats. Coconuts and the oil palm furnish three soft fats and their cultivation in plantations in the East Indies and in West Africa should be steadily extended. The fat of the cacao bean is similarly a cultivated product and there are a number of other tropical seed fats which are similarly solid at our normal temperature, the cultivation of which could be undertaken if it were found desirable. Of the edible fatty oils, those from the groundnut (to which further reference is made below) from sunflower seeds and from seeds of some other annual and perennial species are suitable for intensive cultivation.

The position is unfortunately different in the ' drying oils ' needed by the paint industries, which have been too dependent upon a single oil—linseed oil—for their requirements (together with tung oil, which has special properties which commend it for certain purposes to varnish-makers). From time to time, other oils such as those of rubber seed, candlenut, stillingia seed, niger seed and some others have been found useful, but have only appeared in comparatively small and erratic quantities. Recent work has pointed to the possible utilisation of ' drying oils ' from other tropical plants, one of which, *Tetracarpidium conophorum*, is a West African vine whose cultivation is now being actively studied in Nigeria. The development of rubber seeds and candlenuts is also being considered, whilst another group of oils (sunflower seed, safflower seed, niger seed) very useful to some sections of the paint industry, is derived from seeds the cultivation of which is being investigated in various parts of Africa and Australia. It should be recognised, however, that plans for the cultivation of any of these ' drying oil ' crops are at the moment less advanced and more tentative than, for example, the cultivation of the oil palm or of groundnuts.

In general, the most suitable regions for producing seed fats lie in the tropics or sub-tropics, since warmth and suitable humidity are usually the conditions favouring most rapid and prolific fruiting of oil-seed bearing species. Therefore a guiding principle should be to grow vegetable fats in regions such as Central Africa or Malaya rather than in cooler climates ; in particular it would appear that agricultural land in this country should not be devoted to oil-seed raising at the expense of other foodstuffs. Thus it seems unfortunate to devote 400,000 acres in this country, as I believe it is proposed to do by 1951, to the growing of linseed. As is well known, supplies of linseed from Eastern Europe and from India no longer reach us, and the remaining source of supply—Argentina—demands an exhorbitant price. But, whilst as a temporary measure it may be well to grow some of the crop here, I maintain that the long-term solution (which admittedly may take ten years to achieve) is to develop the production in other parts of the Commonwealth of some of the alternative oil-seeds to which I have just referred. Of these, conophor and candlenut oils at least are fully equal to linseed oil.

At this point one may also refer to soya bean oil, the production of which has been much discussed. From a British standpoint I am inclined to believe that there is not much point in it. Soya bean oil is not as suitable as, for example, groundnut or sunflower seed oil to the edible fat manufacturer, nor is it so useful a ' drying oil ' as some of those mentioned above. In the United States the bean is grown for other purposes to an extent which provides 700,000 tons or so of the oil yearly, and this naturally has to be absorbed if possible. In this respect our conditions are different, and our choice of oil-bearing seeds, when all the potential resources in Africa and elsewhere are considered, is correspondingly wider.

If the choice of warmer regions for oil-seed growing be the correct one, we come naturally to the very big undertaking in this direction which has been commenced in Tanganyika in connection with groundnuts. Here it is hoped eventually to produce from 3,000,000 acres of land reclaimed from jungle an annual crop of 600,000 tons of groundnuts on a rotational basis which will include the interim growing of a lesser, but still substantial, quantity of, *inter alia*, some annual oil-seed crop such as sunflower or sesame. The operation is still in an early stage of development and, as might be expected, the difficulties of clearance and preparation of the soil have been formidable, but are being steadily overcome. If we can imagine a similar project to convert 3,000,000 acres of, say, slum property in this country into land producing half-a-million tons of cereal or other crops, we can hardly suppose that hopes would have been encouraged that in a year or two any substantial proportion of the final output would be achieved. Yet, unfortunately, when this scheme was first planned an impression was given that its execution in a Central African hinterland should lead to notable quantities of ground-nuts being produced within a short time of its inception. When this did not happen and preliminary work in the first year lagged considerably behind schedule (not surprisingly in the circumstances at the outset of such a project), correspondingly over-deprecatory statements appeared from other quarters with regard to the scheme. Whilst utterances of both these kinds had thus been made in circles where one would have hoped to find more balanced and better-informed judgment, others (usually with evidently no particular knowledge of the matter) contributed their views (mainly deprecatory) to the public press in some quantity. I refer to these efforts of the pen and the armchair only because, in one of the rare instances which showed appreciation of the inherent difficulties of the problem (in a letter to the *Daily Telegraph* of June 19th), there occurred two sentences which seem worth quoting here : ' What is astonishing to any one with a knowledge of what these things mean is the extent to which these difficulties have been tackled and, in the main, overcome ' ; and the concluding sentence : ' My only regret is that a start was not made half-a-century ago.'

In this last sentence the writer of the letter puts his finger on the ultimate cause not only of the teething troubles of the Tanganyika groundnut project but also of our present lack of supplies of oil-seeds as a whole. Had systematic, scientific development of oil-seed cultivation in the tropics been pursued on a sufficient scale and with the necessary drive during the past twenty or thirty years, let alone fifty years, the position now would be very different. I have tried, by tracing the development of the oil-seed industries, to show what in fact took place and how the present situation has arisen. For once, perhaps, we need not feel that British initiative has lagged very far behind that of any other country. As I have shown, deliberate cultivation of oil-seeds for the primary purpose of fat production is a comparatively recent development even in the United States. When (I will not say if) the Tanganyika scheme reaches successful fruition it will serve as an example to be followed up in other areas and with other oil-seed crops ; but it will also, let us hope, establish once for all the principle that, for us in Britain, production of fat by growing oil-seeds is a branch of agriculture

as important as, and in some respects more intricate than, that of other food crops—and that the best location for oil-seed crops is in tropical or sub-tropical regions.

It will take a long time to bring such projects into full operation ; but there is no short-term solution to the problem of increasing fat supplies. The more determined and comprehensive approach made to the long-term end of much increased, scientifically-controlled, oil-seed crops from the Commonwealth, the sooner, nevertheless, may we look for some amelioration in the general fat supply position. Evidence that our own intentions are serious and on a comprehensive and extensive basis will, it may be supposed, have some salutary influence on those few nations which have an exportable surplus of fats for which they at present expect an excessive price. Other sources of supply, still affected by the consequences of the war, will also return towards, and in some cases may exceed, their pre-war normal production, and some of the produce (e.g. copra, palm oil, whale oil) will be available to us. In India, the export of fats and oil-seeds was suspended by the former Imperial Government owing to the onset of famine conditions. It has been said that in any case any increase in the standard of diet in India will absorb such surplus fat as may be produced there ; but such general increase is bound to be slow, and India will probably sooner or later desire to trade her products (of which oil-seeds are an important proportion) for other raw materials, for machinery, and so on. Therefore it may well be that to some extent we may again obtain a certain quantity of fat supplies from her as time goes on. Consequently, whilst convinced that the long-term major projects are indispensable to the solution of the problem of our fat supplies, I suggest there is reasonable hope that, within the next few years, the acuteness of the fat shortage will commence progressively to lessen.

Conclusions

1. It is important that the supply of foods whereby fats (unpurchased as such) are normally taken in the diet—milk, eggs, bacon, meat and poultry—should be increased as much and as soon as possible.

2. Of fats as such, imports of butter and whale oil, and perhaps of lard and tallows (suet), may be expected to increase beyond their current limits but are not likely to exceed, and in some cases may not reach, the pre-war quantities.

3. The main source of expansion in fat supplies for Britain lies in the extended development of scientific cultivation of appropriate oil-bearing plants.

4. Such cultivation should be concentrated in tropical or sub-tropical regions of the Commonwealth, and must be envisaged on a scale comparable with the ground-nut scheme now going forward in Tanganyika.

5. Fats for edible and detergent needs are already known in sufficient variety ; here it is a matter of extending the crops of oil-seeds of the sorts already used. For ' drying oils ' for the paint, etc., industries, crops which have hitherto not been grown in quantity for this purpose are required (e.g. conophor, candle-nut, sunflower, safflower, etc.) ; the problem is thus somewhat more novel than in the previous category, but the quantities are not so large.

6. Short-term remedies for the general fat shortage do not exist. The long-term solution indicated appears to be the only sound policy, but there is reasonable likelihood that, given active development of such long-term projects, there will also develop some progressive general amelioration of the position.

FUNGI AND THEIR ECONOMIC IMPORTANCE

By Professor F. T. BROOKS, C.B.E., F.R.S.

Under the auspices of the Dundee Naturalists' Society and the Dundee Horticultural Society, Professor Brooks delivered the Alexander Pedler lecture on October 7, 1948, at the invitation of the Council of the British Association. The following is the text of the lecture, which was illustrated by lantern slides.

Fungi, familiar to all as moulds, yeasts, mushrooms and toadstools, are an immense group of organisms rivalling the flowering plants in numbers and diversity of species. Unlike the flowering plants they are devoid of chlorophyll and cannot make use of the carbon dioxide in the atmosphere. They obtain their carbon either from dead organic matter, living as saprophytes, or from plants or animals, living as parasites. Otherwise their nutritive requirements are much the same as those of green plants. Among their many activities fungi help to disintegrate plant remains, and in this respect, as well as in others, play an essential rôle in the general biology of the soil. Fungi reproduce themselves by spores, bodies of microscopic size, usually consisting of a single cell, which are disseminated by water, mechanical contact, or more frequently by air currents. Fungus spores are commonly present in the air, and aeroplane flights have shewn that they occur at high altitudes in the atmosphere. It is not surprising therefore that such foods as bread, cheese, etc., become covered with a growth of moulds if kept in a damp atmosphere for a few days at a suitable temperature. The mycelium or vegetative growth of a fungus usually consists of fine threads which are sensitive to desiccation, hence the need for dampness to promote development.

Nearly all food substances used by man are liable in storage to deterioration by saprophytic fungi as well as by bacteria unless certain precautions are taken. Desiccation prevents the growth of moulds through the absence of water, refrigeration checks development because these organisms cannot grow at very low temperatures, sterilisation by heat, as in canning and bottling, kills their germs, and the incorporation of large amounts of sugar in jam provides such a concentration of this substance as fungi cannot tolerate. Unless measures of this kind are adequately carried out damage by moulds is certain to occur. Two illustrations may be given of the exacting nature of these requirements for protection against mould deterioration. During the 1914–18 war, when the submarine campaign was at its height, there were great delays in the voyages of the ships bringing meat to this country from the southern hemisphere. In those days refrigeration control was less perfect than it is to-day, and with the extension of the time required for transport, much of the meat was found to be mouldy on arrival and was liable to condemnation by sanitary inspectors. The growth of these moulds on the meat, however, was entirely superficial and harmless, and when unaccompanied by bacterial contamination, much of the meat was saved for human consumption by trimming the carcases. Incidentally certain of these moulds were found to be capable of growth at several degrees below the freezing point of water. With improvements in refrigeration, shortening of the voyages, and attention to hygienic conditions in the abattoirs, which were the chief source of the mould spores that alighted on the meat, mould damage to imported meat is never heard of now. The other illustration concerns the bottling or canning of certain kinds of fruits, especially plums. In a factory processing these fruits by heat sterilisation in the usual way a few years ago it was found that the fruits completely disintegrated with storage and became useless. The damage was traced to a certain mould fungus, *Byssochlamys fulva*, hitherto unknown to science, the spores of which are unusually resistant to heat. Whereas a temperature of 75° C. for half an hour kills nearly all mould spores a considerably higher temperature is needed to kill those of *Byssochlamys fulva*. On the discovery of these facts the temperature of sterilisation was raised, and since then there has been no further trouble with this mould.

Fabrics of various kinds such as cotton goods, paper, bags made of jute fibre, and timber used for structural or other purposes are all liable to attack by fungi under moist conditions, sometimes resulting in complete

disintegration. In the damp tropics cotton cloth rapidly becomes spotted or 'mildewed' by the growth of various moulds. This defect is now overcome by incorporation of an antiseptic substance into the cotton goods, the first successful application having been devised by the Cotton Industry Research Association. It was a common and melancholy experience during the recent war to find that sand-bags filled with soil in connection with Air Raid Precautions became completely rotten in a few months. This was due to fungi in the soil attacking and completely distintegrating the fibres of which the bags consisted. Subsequently methods were devised to impregnate the bags with antiseptic substances, by which the bags were maintained in good condition for a relatively long time. Everyone is familiar with the fact that railway sleepers are impregnated with creosote in order to prevent decay, otherwise the sleepers are disintegrated by fungi long before their mechanical life is exhausted. Creosote is used for this purpose because it contains substances which are highly toxic to fungi. The decay of timber used for structural purposes in the lower parts of buildings is an all too familiar phenomenon. Several fungi are involved, the most important of which is the Dry-Rot fungus, *Merulius lacrymans*. The term Dry-Rot is in some sense a misnomer, for this fungus, like others associated with timber decay, cannot begin its onslaught except under moist conditions, although after establishment it can attack timber in a relatively dry state. As is well known, Dry-Rot usually starts in a cellar or under a floor where there is an air space; the attack is most insidious and frequently escapes observation until the floor or sometimes even the entire building collapses. The Dry-Rot fungus penetrates the wood and completely disorganises it, reducing it to a mass that crumbles between the fingers. Fungi of this kind can only establish themselves on woodwork in a humid atmosphere devoid of ventilation. Provided there is free ventilation and no excess of water around the woodwork the Dry-Rot fungus cannot develop, but if ventilation is defective even seasoned hard-wood will succumb in the course of time. With badly seasoned soft-wood collapse is very rapid. Timber used in houses cannot be creosoted because of the offensive odour, and the cost of impregnating it with other anti-fungal substances is generally prohibitive. Hence in order to prevent Dry-Rot adequate attention must be paid to ventilation in the lower parts of buildings. Dry-Rot has been a bane in other respects in the past, notably in wooden ships. During the Napoleonic wars the Navy had serious trouble with the incidence of Dry-Rot in the warships. In mining operations underground large quantities of timber are used, and the length of useful life of this timber is much reduced owing to attacks by a variety of fungi. Timber is becoming more and more a valuable commodity so it is important to preserve the life of this mine timber as long as possible. Much attention has been paid to this matter in the South African gold mines in recent years, and investigators have devised economic means of impregnating the timber with antiseptic substances, resulting in greatly lengthening its useful life underground.

Fungi are sometimes very destructive to forest trees, either killing them outright or rotting the timber before the trees are felled. But there is one species, *Fistulina hepatica*, the beef-steak fungus, so called because its large edible fructifications have the colour and consistency of steak, which actually enhances the value of the wood of an oak tree into which it has permeated; it stains the wood without disintegrating it, producing 'brown oak' which is much valued for decorative purposes. Another fungus, *Chlorosplenium aeruginosum*, stains dead hard-wood in temperate forests a bright emerald green colour without softening it. Such wood was formerly used for ornamental purposes under the name of Tunbridge Ware. Pieces of wood lying on the ground in British woodlands are often 'greened' in this manner.

To turn now to some highly beneficial aspects of fungi as they affect man: early in the history of man certain fungi were found to be edible and were used as food, as they still are. Man also discovered that by exposing certain plant extracts, *e.g.* fruit juices, to the air exhilarating drinks were obtained. We now know of course that these extracts contain sugars and that they become spontaneously infected with yeast cells from the air, resulting in a process of fermentation and the formation of alcohol. In this way wine, cider, beer and other beverages came into existence. Yeasts, which are a peculiar group of fungi, play an essential part in the production of alcohol. It was also discovered that if yeast is put into dough and allowed to ferment therein before baking, the bread became porous and more palatable. Incidentally the dough contains small quantities of sugar which are fermented by the yeast to produce bubbles of carbon dioxide and alcohol. The bubbles render the bread porous, and the residues of carbon dioxide and alcohol are completely dissipated in the process of baking. Apart from making alcoholic beverages there are now great fermentation industries based on yeast, which in addition to providing yeast in

quantity produce large amounts of carbon dioxide and alcohol that are used for a variety of purposes. There is also prospect of making industrial alcohol in the tropics by fermenting some of the plant materials which are so abundant there. In addition to forming alcohol from sugar yeasts produce several other interesting substances, usually in small amount, in the course of their metabolism. One of them is glycerine, which by altering the nutrition of the yeast can be produced in commercial quantities. During the first world war, when the Germans were short of the fats from which glycerine is usually obtained, they made large amounts of glycerine for their explosives by the activity of yeast. Subsequently this process for the manufacture of glycerine was also developed on a commercial scale in this country. Under suitable conditions yeast grows at an enormous rate producing large amounts of protein and certain vitamins from relatively simple substances. It is not surprising, therefore, that yeast preparations are used for human consumption, for the proteins are of high quality and the cells are well provided with the B vitamins. During the recent war some British botanists, incarcerated by the Japanese in Indonesia, alleviated certain deficiency diseases by growing yeast on a considerable scale in plant extracts, and in this way saved the lives of many of their fellow prisoners[1]. The value of yeast as human and animal food has been recognised in other ways. A yeast known as *Torulopsis utilis* is particularly useful in this respect. A few years ago a factory was established in Jamaica to grow this yeast on a large scale from molasses and certain salts. The yeast can be incorporated in biscuits to serve as human food or can be added to the ration of animals. Incidentally a particularly large-celled form of this yeast has been obtained by treatment with camphor. This leads to the formation of a greater bulk of yeast in the process of fermentation.

Some mould fungi, *e.g.* species of Penicillium, play an important part in the maturation of certain cheeses. Another fungus, *Monilia sitophila*, is often incorporated into cakes made from peanut flour in Java in order to render the proteins more readily nutritive: for this purpose the cakes are exposed to the air, thereby becoming spontaneously infected by this common tropical fungus.

The best known product of a fungus and the most beneficial to mankind is Penicillin, discovered some years ago by Sir Alexander Fleming and elaborately investigated clinically and chemically by Sir Howard Florey and his colleagues during the early part of the recent war. Penicillin is produced by a greenish mould known as *Penicillium notatum*, and is secreted into the medium on or in which the fungus is growing. Fleming found that in extreme dilution penicillin inhibited the growth of certain kinds of pathogenic bacteria, especially those responsible for blood poisoning. It does not, however, prevent the growth of certain other pathogenic bacteria, *e.g.* those responsible for tuberculosis and typhoid fever. It was subsequently found that penicillin is completely harmless to human tissues, so that it was of supreme therapeutic value in certain kinds of bacterial infections, especially those arising from war wounds. Information about the production of penicillin was given to the United States and Russia during the war, and development on a large scale first occured in the former country. Since the war, however, large penicillin-making plants have been established in Britain, so that adequate supplies are now available here. Much work has been done recently to determine the optimum nutritive conditions under which *Penicillium notatum* produces the maximum amount of penicillin. Certain other allied fungi are now known to form penicillin during their growth, but only on a small scale. The chemical constitution of penicillin has recently been determined, but it is a very complex substance and it is unlikely that chemists will be able to synthesise it economically in the near future. Penicillin is said to be an antibiotic substance because, being produced by a micro-organism, it prevents the growth of certain other micro-organisms, *e.g.* bacteria or fungi or sometimes both. Much attention has been paid recently to the possibility that other fungi and bacteria secrete other antibiotic substances. Many such substances are now known, but with a very few exceptions all of them are too toxic to human tissues to be used clinically. One exception is Streptomycin, used against tubercular meningitis, which is produced by *Actinomyces griseus*, a soil-inhabiting organism more akin to the bacteria than to the fungi. One other antibiotic substance may be mentioned, Claviformin or Patulin, which, produced by moulds such as *Aspergillus clavatus* and species of Penicillium, inhibits the growth of certain other fungi. There is some promise that claviformin may be used to prevent the invasion of plant roots by certain kinds of pathogenic fungi.

In addition to antibiotics mould fungi produce many other interesting substances in the course of their metabolism, some of which are obtained on a large scale in this way. Citric acid is produced during the growth of

[1] L. J. Audus, 'Biology behind Barbed Wire.' *Discovery*, July 1946, p. 211.

Aspergillus niger, a common black mould in sub-tropical countries. Nowadays citric acid, which is used for a variety of purposes, is chiefly obtained from this mould whereas formerly its only source was the juice of lemons. Other mould fungi such as *Aspergillus oryzae* and *Rhizopus oryzae* are rich sources of diastase, the complex of enzymes that converts starch into sugar. In the Far East these fungi are used to change the starch in rice and other plant products into sugar, preparatory to alcoholic fermentation by yeast. In the manufacture of yeast on a large scale in the Japanese internment camps referred to previously it was first necessary to treat the rice grains with *Rhizopus oryzae*, the spores of which commonly occur in the atmosphere of those regions.

A curious discovery has been recently made concerning the olive-green mould *Penicillium digitatum* which rots lemons and oranges. A mouldy fruit or a culture of this fungus hastens the ripening of contiguous healthy fruits owing to an emanation, probably ethylene, which is given off by the fungus. This discovery may have a practical application as ethylene in small amount is already used to facilitate the maturation of certain fruits.

Some fungi require the addition of vitamins to the culture medium for effective growth, although others are able to manufacture these accessory food substances for themselves. Some of them are so sensitive to the presence or absence of certain vitamins that they can be used to determine the relative concentration of specific vitamins in the surrounding medium, a method which is known as bio-assay. For instance the mould *Phycomyces blakesleeanus*, which cannot grow in the absence of vitamin B_1, is commonly used to determine the concentration of this vitamin in materials of unknown potency. This is done by comparing the growth of the mould in a medium containing a given concentration of the vitamin with that in a comparable medium containing a known amount of the material under test.

Another example of bio-assay concerns the mould *Aspergillus niger*, which requires minute quantities of copper for effective growth and sporulation. Land recently reclaimed from the sea in Holland is often deficient in copper and will not therefore sustain certain crops for which this trace element is essential. Crops grown on such land suffer from ' reclamation disease ' as it is called in Holland. Nowadays the degree of copper deficiency in these soils is determined by tests with *A. niger*. In this way the correct amount of copper salts to be added to the soil to make it fully productive can be determined.

A few other fungi are used medicinally, the most important of which is ergot, *Claviceps purpurea*, a fungus which parasitises the flowers of cereals, especially rye, and grasses. The fungus replaces the ovaries by a hard mass of tissue, the ergots of commerce, which contain a variety of alkaloids. One of these alkaloids, ergometrine, is valuable medicinally, and can be extracted. The chief source of ergot is from rye in Spain and Hungary where the fungus is sometimes artificially propagated. For a period during the recent war it seemed doubtful whether adequate supplies of ergot would be available. Efforts were therefore made in other allied countries to produce supplies of ergot, but the fungus sometimes failed to produce the valuable medicinal alkaloid, possibly because of unfavourable climatic conditions. Ergot also contains dangerous alkaloids and if it is incorporated in flour, bread made therefrom is liable to give rise to serious diseases if eaten habitually. Before the insidious nature of this fungus was realised cases of ergot poisoning from contaminated rye bread were by no means uncommon. The Chinese use a considerable variety of fungi for medicinal purposes, but I have no knowledge as to whether these remedies are really efficacious.

Many fungi are used as human food, *e.g.* mushrooms, certain toadstools, puffballs, morels and truffles. Although their nutritive value is low they add variety to diet and connoisseurs appreciate their flavours. Primitive races eat certain other fungi. Darwin records in his story of the voyage of *H.M.S. Beagle* that early in the nineteenth century one of the chief foods of the natives of Tierra del Fuego was a bright yellow fungus (*Cyttaria darwinii*) that grew in quantity on the branches of the southern beech (*Nothofagus* spp.). The aborigines of Australia dig up the large masses of a certain fungus (*Polyporus mylittae*) from the soil and eat them, this being known as black man's bread. As is well known, truffles grow underground in association with the roots of oaks and beeches. They are somewhat rare in this country, but are more abundant in parts of France where there is a kind of method of cultivation. From time to time new plantations of trees are established and the soil is inoculated with soil from an area where truffles abound. In due course truffles develop in the new plantations. Truffles are often sought with the aid of specially trained dogs or even pigs as these fungi emit an odour which is attractive to the animals. The Chinese and Japanese cultivate certain other kinds of edible fungi on dead wood. The mushroom (*Psalliota campestris*) is now cultivated on a large scale in cellars, caves, sheds and other buildings, and it is noteworthy that the fructifications

develop perfectly in the complete absence of light. Other fungi similar in form to the mushroom are called toadstools, which occur in great variety in woods and pastures, especially in the late summer and autumn. Many of these toadstools are edible, and are commonly eaten on the Continent where special markets are sometimes available for their display. In this country, however, they are rarely used as food except by connoisseurs, perhaps because of the possibility of confusing them with certain poisonous forms. In point of fact only a few toadstools are poisonous, the most important one being *Amanita phalloides* with an olive-coloured cap, which usually grows under oak trees. If *A. phalloides* is eaten death almost invariably ensues. Another dangerous toadstool is *Amanita muscaria*, with a scarlet cap, found chiefly under birch trees and conifers, but although it may cause serious illness it is rarely fatal. Although such toadstools have superficially the form of mushrooms their other characters are so different that it is difficult to understand how they come to be gathered for food, as occasionally happens with distressing results.

Many of the toadstools found in woods play a very important part in the life of the trees, for their mycelia form intimate associations or mycorrhizas with the roots. The fungi in fact are the means by which the roots obtain certain nutritive substances from the soil, and it is now recognised that unless young trees form appropriate mycorrhizal associations they do not thrive. Much attention is now paid to this matter in forest nurseries and every effort is made to ensure that the correct mycorrhizal association is established at an early stage. In a successful mycorrhiza the root and the fungus live a harmonious life together and both partners probably benefit from the association. It may be that in the humus soils of woods, which are permeated by a great variety of fungi, the appropriate mycorrhizal fungus is more efficient in absorbing nutrients from the soil than the normal absorbing cells of the root would be. Whatever the true biological explanation of these curious associations may be it is clear that they are of supreme importance in the life of many trees.

Herbaceous plants, too, sometimes have particular fungi associated with their roots, notably orchids. But here the mycorrhizal fungus plays an additional rôle. It has long been known that orchid seeds, which are extremely small, are difficult to germinate. If, however, they are sown in contact with a culture of the appropriate mycorrhizal fungus they germinate readily. The fungus serves to make the food substances in the seed available so that the embryo begins to develop. This method has been commonly used in the propagation of orchids on a large scale, especially by growers who produce new types of these plants by hybridization. Alternative methods, however, are now available for ensuring germination of these minute seeds.

Many fungi are true parasites, that is they invade the tissues of the higher animals, including man, and green plants in a destructive manner. In the causation of human disease fungi are not nearly so important as bacteria, although a few horrible diseases are caused by them, especially in the tropics. Skin diseases, of which ringworm is the commonest, are not infrequently caused by fungi even in temperate countries, but medical mycology in general is a rather neglected field of study. On the other hand much attention has been paid in recent years to the investigation of the fungus diseases of plants of economic importance and the means of controlling them. Apart from the hazards of weather and attacks by insects the most destructive agencies in reducing crop yield are parasitic fungi and viruses. There is hardly a single crop or ornamental plant or tree which is not liable at some stage in its life to serious attack by one or more parasitic fungi. Crop failure may be complete or partial, but notwithstanding amelioration in some respects the losses due to the incidence of parasitic fungi are still enormous. Fungus diseases have actually wiped out entire cultivations in the past, notably that of coffee in Ceylon and Malaya some years ago owing to attack of the foliage by a certain rust fungus, *Hemileia vastatrix*. The coffee bushes were so impoverished by this onslaught that they became unprofitable, and coffee is no longer grown on a commercial scale in those countries. At the present time the banana industry in Jamaica and Central America is threatened with extinction owing to invasion of the roots by the fungus *Fusarium cubense* from the soil, which causes a complete wilt of the plant. Every now and then a destructive fungus appears in a country in which it is not indigenous and under different environmental conditions it may be even more disastrous than in its native home. A few years ago a new and very serious disease of potato tubers in the high Andes of S. America was described, caused by the fungus *Thecaphora solani*, which persists in the soil. This territory, the home of the potato, has conditions of temperature and rainfall similar to those in Europe, and it might be disastrous if this disease were introduced into other countries. Recently blister blight of the tea plant, caused by *Exobasidium vexans*, has appeared in Ceylon and southern India, much to the consternation if the planters,

where it may become a serious menace. The incidence of many fungus diseases is dependent on weather conditions. This is notably the case with potato blight caused by *Phytophthora infestans*. In a dry summer this fungus hardly appears at all, but in a wet season it spreads epidemically, destroying the foliage prematurely and infecting the tubers. For an epidemic of this kind to be established there must be an original source of infection and weather conditions must be suitable for the production of large masses of spores and their dissemination over wide areas.

Some of the chief ways of controlling these fungus diseases of plants will now be considered. The most important one is to try to breed varieties of crop plants which will be resistant to attack. All crop plants which have been long in cultivation comprise innumerable varieties which differ markedly in their susceptibility to specific diseases. Varieties which are resistant to disease are often inferior as regards yield or quality, but it is possible for the modern plant breeder to combine the resistant quality of one variety with the other valuable qualities of the susceptible type. Sometimes the wild progenitors or allies of the particular crop are also used in making these desirable combinations. Much progress has already been achieved along these lines, perhaps the most notable success being the breeding of wheats resistant to the rust fungus *Puccinia graminis* in N. America, Australia and certain other countries. At the present time this rust is of comparatively little importance in Britain although 100 years ago or so it caused heavy losses in wheat cultivation. In the important wheat belt of N. America it was liable to cause serious epidemics until a few years ago, but with the introduction of new resistant varieties millions of bushels of grain have been saved, a factor of great importance in the world shortage of food. With wart disease of potatoes, caused by *Synchytrium endobioticum*, it was early discovered in this country that some varieties are immune to attack. Nowadays when new potato varieties are produced they are tested for susceptibility to or immunity from this disease, and only those which are immune are released for future use. At present much attention is being paid at Edinburgh and Cambridge to the possibility of breeding potatoes resistant to blight by combining the desirable qualities of present commercial types with the resistance to this disease possessed by certain Mexican and other allies of the domestic potato. Some progress has already been achieved in this respect. In Scotland the devastating red-core disease of strawberries, caused by *Phytophthora fragariae*, has been successfully combated by the use of resistant varieties bred at Auchincruive. The only present hope of staying the progress of the wilt disease of bananas in Jamaica lies in breeding a good commercial type which is resistant to attack ; much effort is being devoted to this end. In breeding plants resistant to fungus diseases it must be remembered that fungi, being living organisms, possess the capacity to change their parasitic proclivities, and there have already been some disappointments in this respect. Still, it is usually possible for the plant breeder and pathologist working together to be prepared for changes in the hostile powers of the parasite.

With certain diseases the fungus can be attacked directly. Some fungi are transmitted by spores adherent to the seed of the crop plant, as in bunt of wheat or leaf-spot of oats, and control is often easy by disinfecting the seed with a fungicide before sowing. Again, parasitic attack on the foliage may often be prevented by spraying it with a fungicide before the onslaught begins. Where potato blight or downy mildew of the vine is liable to be severe the foliage can be protected by applications of a copper fungicide, and in commercial apple cultivation the fruitgrower regularly sprays the trees with a copper compound or with lime-sulphur to prevent the establishment of the scab fungus (*Venturia inaequalis*) on the foliage as otherwise it passes to the fruits and renders them unsightly. Soil-inhabiting parasites are notoriously difficult to control but sometimes a simple treatment of the soil is efficacious, such as for instance the addition of lime to an acid soil to check club-root of turnips and Brassicae, caused by *Plasmodiophora brassicae*. Extension of the interval between two successive crops of the same susceptible kind checks the ravages of certain root parasites. Lastly, destruction of the sources of infection as far as practicable is the prime principle of plant hygiene. In this country the intervention of the barberry bush is necessary for the completion of the life history of the stem rust of cereals, and the great reduction of this disease since the early years of the nineteenth century is partly bound up with eradication of these bushes in the neighbourhood of cereal crops. A slight recrudescence of this disease in some parts of Great Britain recently is associated with barberry bushes which have not yet been eradicated. Certain parasitic fungi can also grow on dead plant debris, as for instance *Stereum purpureum* the cause of silver-leaf disease of plum trees. It is wise therefore for the fruitgrower to destroy all dead woody material on which this fungus can fructify as thereby the supply of infectious spores in the air is greatly reduced.

CONSERVATION OF THE CHEMICAL ELEMENTS[1]

BY

PROF. J. D. BERNAL, F.R.S.

AND OTHERS

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THE extremely rapid increase in the utilisation of materials of all kinds in modern industry and agriculture is beginning to be on such a scale that it affects the actual available supply of many of the elements and threatens to exhaust their most concentrated deposits in a matter of decades. If the rate of exploitation continues to grow at the present speed or faster, it will be absolutely necessary to change the method of utilisation of many of the elements. What applies to the world as a whole applies with much greater force to countries of relatively limited resources such as Great Britain. For purely economic reasons it is important to conserve all economically valuable resources, both of materials produced at home and in the Colonial empire, which are consequently available for export, and those that require to be imported. It may therefore be worth while to examine in a very general way the principles underlying the utilisation of elements in a modern economy and to suggest the enquiries and actions that might be taken to ensure that they be used with the greatest economy.

In an industrial system, as in a biological or even in a purely geochemical system, elements for the most part do not remain in any fixed place, but undergo a cycle in which they are combined in different ways with other elements and where they are concentrated, dispersed and again concentrated. The geochemical, biological and industrial cycles are of very different periodicity and from the human point of view the first may be taken largely as a constant, concentration and dispersal processes occurring by geochemical forces only being too slow to affect our present human time-scale. Biological cycles are under slightly more control but for the most part they only affect certain elements which are common in soil or atmosphere, such as carbon, oxygen and nitrogen, though with regard to two elements, potassium and phosphorus, the biological and industrial cycles are very closely connected.

Industrial cycles for the utilisation of any element have certain common features, though each element has its own special peculiarities. The phase of the cycle may roughly broken down into those of (1) collection, (2) fabrication, (3) use and (4) recovery.

(1) The collection of most elements is by means of mining operations, whether from metallic ores or from such materials as coal, phosphate rock and gypsum. Very naturally the first to be exploited are the richest and most easily usable ores, but now, with the exhaustion of many of these the tendency is to look towards poorer and poorer sources. In the process of mining a certain more or less avoidable waste occurs in material left behind in the ground, or dumped as incapable of further extraction.

(2) What is recovered passes on to the next stage of smelting and fabrication into a usable form. In this stage also a certain waste of the element usually occurs, though here, owing to the concentration of the work, recovery is more easy.

(3) The element may appear in use in two forms, as a metal object such as a steel rail, or as a chemical commodity such as cement or sulphuric acid. The cycle for these two types of utilisation is, of course, entirely different : in the first case it is the physical properties that are significant, in the latter the chemical, though in some cases such as cement both properties are involved. It is in the third stage of use that the greatest dispersal of the element occurs. Apart from the common elements such as iron, elements are either found in small parts widely dispersed or are distributed for chemical use in a vast number of processes occurring in different places. A certain amount of waste necessarily occurs during use. This may be small in proportion, as in the wear of metal parts, or it may involve the total destruction and dissipation of the material, as in the use of tetraethyl lead in petrol.

(4) The fourth or recovery phase has been incidental in the past, and has affected only a small number of elements either because they were very valuable, like gold, or because they were like iron, so common as to get in the way and demand disposal as scrap. Recovery has always been treated as an incidental *ad hoc* problem. What we need is a general study of the principles of recovery and its systematic application to all elements with

[1] Substance of contributions to a symposium of the Chemistry Section at Brighton on September 13, 1948.

due priorities. The recovery process is limited by two major factors; one is permanence and the other dispersion. Many materials such as cement can be used effectively once only; others such as steel for many structural purposes become embodied in structures lasting for tens or hundreds of years and are for practical purposes out of the recovery cycle. The largest loss, however, must occur where elements originally concentrated are dispersed into such small pieces or alloyed or blended with other elements so that their recovery becomes a highly uneconomic process. How far this is necessary is a thing that needs to be examined. This is particularly true of elements used in chemical processes where they become increasingly diluted and thoroughly mixed with others. What is needed is a careful examination of every phase of the utilisation cycle in close conjunction with that of the whole industrial process and with particular regard to the possibilities of research in making processes, particularly the recovery process, economic.

Many of the processes of mining and smelting come directly and traditionally from older processes belonging to the prescientific age and they have been largely improved in detail without perhaps a sufficiently fundamental examination of the results aimed at in the light of the total modern available techniques, both in engineering and chemistry. This applies particularly to the commoner processes in ferrous metallurgy. In general, mining and metallurgy should rapidly be assimilated as part of a more scientific physicochemical technique which is developed in the first place from the newer branches such as those of magnesium or oil chemistry. Such changes, however, are likely to occur in any case.

The place to look for new economy will probably be in the utilisation of the different elements. In the past the price mechanism has acted in some degree to ensure that an element is only used when it is impossible to find a cheaper substitute, but in a controlled economy this is increasingly difficult to do, and in any case was never done very well because there was for almost every product a strong tendency to insist on its use wherever possible in a general search for markets, and this actually promoted diseconomy of use. The most important new idea, which is essential to any effective utilisation of the elements, is that no element should be employed where its particular properties are not utilised to the full, and further that such utilisation will, even in a comparatively short run, be actually to the advantage of the producers of this element because, in the resultant cheapening of all production and processes, a greater effective demand for the element is bound to appear. A way of ensuring such economic use of elements is by the extension of functional specification to the widest number of cases, that is, not a specification for the use of such and such an element, but in specifying the fabrication of a product with such and such physical or chemical properties. There are a few cases where the peculiar properties of a particular element seem absolutely essential—the use, for instance, of mercury as a metallic liquid or germanium as a semi-conductor. But in most cases there is a fairly wide range of substitution, and it always should be possible to adjust the substitution in relation to the existing and foreseen shortages of particular elements.

To these general considerations can be added some concerned with groups of elements and with elements of particular importance. From the economic point of view we can divide the elements into four major groups. First of all there are those elements which are common and also found in unlimited deposits of high concentration. Of these we must reckon such elements as calcium and silicon in the earth, sodium and chlorine in sea water, nitrogen and oxygen in the atmosphere. From this point of view of conservation we need not seriously consider them. The problems they involve are not those of material saving, but of energy—energy required to prepare them in the form in which they need to be used, such as calcium carbide or soda.

The second group are those elements of unlimited abundance on the surface of the earth, but which are found in high concentration only in relatively limited deposits,—relatively, that is, to the quantities required in modern industry. This group includes the two key elements of modern civilisation, carbon and iron, but also aluminium, magnesium and potassium among the metals, and phosphorus and sulphur among non-metals. It is in this group especially that the tendency to move to poorer and poorer sources is most marked. Carbon stands rather apart from the others in that, for the time being at least, it is its use as a source of energy, and therefore its existence in the elementary form, that is most important. With all those elements there is no serious danger of exhaustion, the danger is rather that the cost of extraction is likely to rise unless some care is taken in conservation.

The third group are rare elements which are found in a concentrated way. This is the case of most of the non-ferrous metals, copper, tin, lead, mercury. Here there is a clear danger of absolute exhaustion and the strongest case for conservation and re-utilisation as well as for the search for substitutes.

Finally there are the great majority of

elements, which are rare and not concentrated. As a consequence in the past they have not entered into human economy, but it is clear that in future materials will be sought for special properties which may only be provided by certain elements. Coming new into utilisation, however, they are likely to be tackled from the start by modern methods and their conservation may be trusted to look after itself.

There are six elements, the problems of whose conservation and utilisation are of the highest importance. These are carbon, sulphur, and phosphorus, iron, tin and lead. Carbon stands by itself and is essentially a case for energy economy. Sulphur, especially in the form of sulphuric acid, is perhaps the key element of the chemical industry. In the past its relative abundance in the native form has led to its extensive and very wasteful use. In peacetime much of it (about 48 per cent.) is immobilised as ammonium sulphate or used up in the making of superphosphate. The remainder pours away into the multiple channels of the chemical and textile industries and disappears by dilution or neutralisation. Now in wartime it becomes the essential ingredient in the manufacture of explosives. At the present moment, though there is no world shortage of sulphur, it represents an important drain on British resources and the problem of its economic production from materials other than the native element, such as spent oxide, flue gases or gypsum, begins to be appreciated. At the same time very much could be done to prevent utilisation certain to lead to dispersion, the substitution of ammonia or ammonium phosphate for ammonium sulphate, for example. Phosphorus is even more critical. Rich phosphate sources are limited and there is a continual drain either in non-utilisation in the soil by conversion to insoluble phosphate, or by passing into rivers and the sea through sewage. The food supply of the world is largely controlled by the amount of phosphate available, and there is consequently a great need for research to cut down these sources of waste.

In the case of the metals such as iron, the problem of conservation may perhaps most easily be solved by promoting better utilisation, that is, by improved specification both of the alloys used and of the structures into which they are built. This, together with a more effective system for collecting scrap, might make the iron cycle a manageable one and prevent shortage of steel becoming the major limiting factor in industrial advance. The cases of tin and lead are different ones. Both relatively rare metals, they are used for specific purposes for which it has proved difficult to find substitutes, but they could be used much more economically. In tinplate, for example, some 75 per cent. might be saved by better preparation of the sheet iron and by tinning on one side only. In lead it may be necessary to redesign our plumbing units to reduce its use to a minimum.

These are mere suggestions for discussion and research. The purpose of this paper will have been served if the problem is seen as one unity, and if appropriate action is taken to deal with it. Since the subject was suggested important steps in this direction have already been taken in Great Britain. The Sub-Committee on Import Substitutes, of which Professor Zuckerman is the chairman, has now been working for some months and undoubtedly has made considerable progress. The conservation and full utilisation of the elements will undoubtedly require a vast amount of research, economic, technical and scientific, and it is to be hoped that the Government committees concerned will already have started that research. The advantage of conservation over other methods of economy is that besides yielding immediate results it makes things easier for the future and thus counteracts the tendency only too natural in times of crisis to sacrifice anything for present values. But it is important that not only Government bodies, but all scientists, particularly chemists and engineers, should realise the nature of the problem and should bear it in mind in every particular task in which they are occupied, and to do this they need adequate information as to the directions in which it would be most valuable that they should bend their efforts.

DR. R. P. LINSTEAD, C.B.E., F.R.S.

CONSERVATION of essential materials is a matter of great importance. I am particularly interested in it because various aspects of conservation are occupying us at the Chemical Research Laboratory at Teddington. Indeed more than half our research efforts is devoted to one aspect or another of this broad problem. My comments, however, are not official, but personal.

Conservation is a subject which calls above everything for informed and responsible opinion. To get this we have to ventilate the subject, to talk about it and above all to think about it. An American expert recently said of his country's attitude towards the subject :

> ' History shows that as a nation we talk a great deal about conservation but are unwilling to put up much cash for it.'

Scientists can ' put up cash for it ' in the form of careful thinking.

The reason for its importance is the great change in the material history of the world during the twentieth century. This has

crept upon us unawares. Man is now making vast raids upon his capital resources. It has been stated that more minerals have been taken out of the ground in the United States since 1900 than from the whole world during the whole of previous history.

The total problem is, of course, vast, because we must know the supply and the technology of each of the 92 elements (neglecting the artificial ones). But, as Professor Bernal has shown, it is not quite so bad as that in practice. The first thing is to find out which are the most urgent parts of the problem, what are the elements of which we are most short and there are two ways of looking at it—general or world shortages, and local or national shortages.

The first need is for full statistics, particularly statistics of world reserves of minerals. These are in general sadly deficient and we can say that we can never be quite sure what the long-range conservation problems are until full economic geological surveys have been made and the results published. Yet, even without full statistics it is easy to pick out plenty of pressing problems.

Suppose it is established that a technologically valuable material, say a metal, is running short. This means that there are insufficient economic sources to cope with demand ; and by economic sources are meant ore deposits which can be worked economically at present world prices.

Seven different kinds of things can be done.

First, on the side of *supply* of the ore we can :

(1) Find more, through exploration and survey.
(2) Use the economic sources more carefully, for example by working up waste and slags.
(3) Use low grade sources.

Turning to the side of *use* of the metal we can :

(4) Use less ; (an example is the use of thinner tin in tinplate).
(4) Stop using ; that is, find a substitute.
(6) Conserve during use (an example is the protection of iron and steel from corrosion).
(7) Conserve after use ; that is recover scrap, trade wastes, sewage, etc.

The term conservation is sometimes applied only to the last two of these ; but it is better to use it to cover the whole seven.

As an element becomes rarer, while still in great demand, its price tends to rise unless improved methods are found for its isolation. The rise in price provides a margin whereby sources and processes not previously economic can be brought in. In general the use of more dilute sources of material will lead to increased costs because of the increased requirement for energy or reagents involved in the act of concentration.

Some of these points can be illustrated by the case of *Lead*, a metal which has been mined in this island for thousands of years, but of which we now produce only a very small fraction of our requirements ; a metal, moreover, of which there is a general world shortage.

Lead is at once a rare and common element. Really rare (it is less abundant than hafnium in the world's crust), it is common to us from its long history, ease of isolation and general usefulness. The metal continues in great demand. To long-established uses in buildings, solder and alloys (including type metal) and ammunition have been added heavy requirements for electric cables, accumulators and for lead tetraethyl. The U.S.A. alone needed about a million tons in 1947, and were able to supply about a third of it in scrap. In spite of this and of the fact that they are the word's largest producers, they were obliged to import about a fifth of their requirements.

No big new sources of lead have been found for thirty years and one can only guess at the world's total resources. The American estimate of their national position is that (on the prewar rate of consumption) their commercial reserves are down to about 12 years' usage and their sub-marginal reserves down to less that 5 years' usage. Of course there are other large producers, Australia, Canada and others, and the metal is in fact widely distributed. But in the absence of new finds of high grade ore it is probable that the present comparative shortage of lead will become intensified in the fairly near future. The price fluctuation is interesting : The price of lead rises in time of war, but whereas it fell after 1918 it is not doing so to-day. It looks as if the era of ' six-cent lead ' is over for good.

There will therefore develop an increasing tendency for lead to be reserved for those special uses in which its unique and highly valuable properties can be fully utilised, and less will be available for those uses in which it has only a marginal superiority over other materials. Lead will become a more prized and valuable material and incidentally a new light will be shed upon the Casket Scene in ' The Merchant of Venice.'

As regards sulphur, there is no world shortage but a national problem. There is an interesting difference between sulphur and most of the metals. Sulphur is used largely in the form of sulphuric acid and this is normally a *carrier* of processing material—that is, it is essential to the *process* but seldom wanted in the *product*.

The main sources of sulphuric acid in this country are well known. There is considerable production from gas works spent oxide (that is from sulphur originally present in British coal); at Billingham from British anhydrite, and from zinc concentrates (which we can consider as being indigenous for our present purpose). But the bulk of the material comes from imported brimstone and imported pyrites. The brimstone involves us in heavy dollar expenditure.

Possibilities which will need to be carefully examined are the recovery of sulphur from coke oven gas and the extraction of elemenary sulphur from gas works spent oxide. There is also the fact that a great deal of the sulphur ultimately goes to waste in the drains and particularly the soil; some, at least, of the usage of sulphuric acid may be avoidable.

What are the lessons to the chemist, and particularly the research chemist? It is clear that much new knowledge will be required for these basic problems to be solved, and in this the chemist, with the geologist and the engineer, will play an essential part.

The chemical problems will be of two kinds. There will be those which depend upon the chemistry of the individual elements concerned. These are obviously important and are not likely to be missed. But attention should also be given to another point. As we move into an age of lower grade sources, there will be an increasing need for basic knowledge of certain *general types* of procedures which can be involved in the concentration and separation of materials. Such processes as flotation; solvent extraction; chemical leaching; adsorption and ion-exchange. These will acquire an increasing importance as the century advances.

Dr. R. Lessing

Sulphur is a typical example of an element which occurs in nature largely in dispersed form and is re-dispersed after utilisation. The bulk of the sulphur compounds used for industrial purposes is drawn from the relatively few natural sources in which they occur in concentrated form and which are at present commercially most readily accessible. Thus, elemental sulphur is produced in Sicily and Louisiana, and combined sulphur as sulphide in many copper and other metal mines. Most of this sulphur is converted into sulphuric acid which in turn reacts with bases or metals, the sulphates formed being locked up in a wide variety of manufactured products or in the ground when used in fertilisers such as superphosphate or ammonium sulphate.

An important source of dispersed sulphur is coal: 200 million tons of coal produced annually in Britain contain at an average of, say, 1·5 per cent., 3 million tons of sulphur. This is equivalent to about 10 million tons of sulphuric acid, nearly 10 times the production of the acid in this country. Only about 100,000 tons of sulphur are recovered in spent oxide from coal gas purification and used for sulphuric acid manufacture. Most of the balance of the 3 million tons escapes with combustion gases unutilised into the atmosphere as sulphur dioxide with a little trioxide, some being retained in the ashes to be dumped on the refuse heap or into the sea.

Means have been worked out for avoiding this re-dispersal of sulphur from coal, by extracting the sulphur oxides from chimney gases. A notable example is the process installed at Fulham Power Station, in which the gases are treated with a chalk suspension to form calcium sulphite, which, in a simple aeration unit, can be oxidixed to calcium sulphate dihydrate, identical with gypsum. The growing importance for the building industry of gypsum as plaster and as an additive to cement, justifies the development of this reconcentration of sulphur as an addition to the natural product mined in this country or in substitution of that imported from abroad.

In gas works this extraction of sulphur dioxide from the combustion gases of the coke fuel used for heating the retorts can usefully be combined with the manufacture of ammonium sulphate. A cyclic process was installed in one of the Manchester Corporation Gas Works in which the suspension of completely oxidised calcium sulphate from the flue gas washer was passed in lieu of water through the ordinary ammonia scrubber thereby yielding ammonium sulphate and calcium carbonate by double decomposition. After decanting the resulting solution of ammonium sulphate the thickened sludge of calcium sulphate with added water was recirculated through the flue gas scrubber. This process for direct ammonia recovery without interposing the production of ammoniacal liquor sets free the corresponding amount of sulphuric acid for other purposes such as superphosphate manufacture. It is, of course, equally applicable to the neutralisation of synthetic ammonia where the synthesis plant is placed in juxtaposition to a large coal consuming plant such as a power station. This work, which was discontinued on the outbreak of war, deserves serious reconsideration by the newly established Gas Council.

At present the bulk of coal sulphur escapes into the atmosphere in form of oxides. An appreciable portion of these acidic compounds involve damage by causing decay of buildings, tarnishing and corroding metals, rotting textile materials, and under certain

atmospheric conditions are a menace to health, as in the disastrous fog in the Meuse valley in 1930. Even that portion, which is dispersed by the wind, and which may well be the larger, must eventually find targets for its aggressive action either in form of basic dust particles in the air or after being washed out by rain and reaching the ground again. In any event it is lost for beneficial utilisation.

Obviously the complete utilisation of 3 million tons of sulphur or even a large portion of it, is a long-term problem. The first step should be the removal of inorganic sulphur, present as pyrites, from coal. This was practised during the war and should be a normal operation in coal cleaning. There remains the inseparable inorganic and the quantitively more important organic sulphur, which of necessity appears in the combustion gases.

It is outside practical politics to consider any scheme for the recovery of 600,000 tons of sulphur from 40,000,000 tons of coal burned in millions of domestic fireplaces. Priority of consideration must be given to the largest point sources of sulphur oxides emission, i.e. power stations, gas works and large or medium sized factories, blocks or flats, offices, hospitals and the like.

The problem should be regarded not only from the viewpoint of national self-sufficiency but also from that of world economy. Vast tracts of the earth's surface are deficient in soil nourishment. To counter the menace of mass starvation immense quantities of fertilisers are required. Apart from potash, those most needed are phosphate and ammonia, both of which are applied mainly in combination with sulphuric acid. Hence the world demand for sulphur must necessarily increase at a steady and rapid rate, and every care should be taken to utilise this element wherever means are available to prevent its dissipation beyond recovery.

EARLY MIOCENE APES FROM EAST AFRICA[1]

By

Prof. W. E. Le Gros Clark, F.R.S.

In 1947, with the aid of a grant from the Royal Society, the British-Kenya Miocene Expedition was organised for the purpose of exploiting the rich fossiliferous sites recently exposed in the Kavirondo Gulf of Lake Victoria. The expedition was directed in the field by Dr. L. S. B. Leakey with the assistance of Dr. I. MacInnes. It led to most successful results, for in the space of a few months many hundreds of fossils were collected. Among these were more than a hundred specimens of extinct apes, which are now in course of study, and the present communication is intended only as a preliminary statement. Prior to discoveries in East Africa, the existence of *large* apes so early as the Early Miocene were not known ; most of those found in Europe and Asia date from the Late Miocene or the Early Pliocene. Since the Miocene Period was of considerable length—perhaps as much as twenty million years—their discovery in the early part of this period has shown that they have an antiquity considerably greater than had previously been supposed. The first fossil apes reported from East Africa were described in 1933 by Dr. A. T. Hopwood, who recognised at least three different genera. With the accumulation of so much new material by the British-Kenya Miocene Expedition, it has now become apparent that in Early Miocene times East Africa was populated by anthropoid apes of many different types, showing an astonishing diversity of form and size. Most of the fossil remains of these creatures belong to a large animal which, judging from the teeth and jaws, must have been comparable in size to a chimpanzee. It is attributable to the genus *Proconsul* previously described by Hopwood, but it is considerably larger than Hopwood's specimen and undoubtedly represents a different species. Still another species of even greater size—equivalent to that of the modern gorilla—has come to light as the result of the 1947 Expedition. Those types may be regarded as different species of the genus *Proconsul*, and they are all characterised by certain peculiarities of the molar teeth, some of which appear to represent local specialisations. But among this wealth of material are a few specimens of another type of ape of a more generalised

[1] Substance of a paper read to Section H at Brighton on September 9, 1948.

kind, which (on the basis of tooth structure) is indistinguishable generically from *Sivapithecus* from the Siwalik deposits in India. This form is of particular interest since, as with certain other mammalian genera such as *Deinotherium*, *Aceratherium* and *Amphicyon*, it serves to link up the Siwalik fauna with the Miocene fauna of East Africa. It is also of interest because in its tooth structure it is more generalised than *Proconsul* and in this respect is more comparable with the Hominidae.

Besides the extinct large apes from East Africa are a number of smaller forms. Some of these (e.g. *Limnopithecus*) show affinities to the modern gibbon. They resemble very closely *Propliopithecus* of the Egyptian Oligocene, and *Pliopithecus* from the Miocene of Europe.

Of particular interest are some of the limb bones discovered in East Africa, for up to recently our knowledge of extinct apes has been practically confined to jaws and teeth. These limb bones consist of the shaft of a humerus, two fragments of clavicle, almost a complete femur and portions of others, and some ankle bones (calcaneum and talus). They evidently belong to one of the large apes (probably *Proconsul*) and are similar in general dimensions to those of a chimpanzee. But they show significant differences, particularly in the slender proportions of the shafts of the long bones, and in certain features in which they resemble those of cursorial monkeys rather than the modern brachiating apes. They appear to indicate indeed, that these Early Miocene apes were lightly-built creatures which had not become specialised for a completely arboreal existence —they were capable of running and leaping with considerable agility, in strong contrast with modern anthropoid apes. These observations have an important bearing on the problem of human evolution since many authorities have argued that, in spite of the evident relationship between the Hominidae and the Pongidae, limbs of human type could hardly have been derived from those characteristic of the modern apes, and on this basis attempts have been made to exclude the group of anthropoid apes altogether from any place in human ancestry. The discovery of the limb bones of Early Miocene apes has made it clear that this argument no longer has the same validity. The British-Kenya Miocene Expedition is continuing its important work during the present season, and more material is likely soon to come to hand.

Postscript.—Since this communication was made, Dr. Leakey has discovered the greater part of the skull of one of the species of *Proconsul*. Since this is the first *skull* of a Miocene ape ever to be found, it ranks as a discovery of the first importance.

MATHEMATICAL TABLES

FINAL REPORT of COMMITTEE on Calculation of Mathematical Tables. Dr. A. J. THOMPSON, *Chairman*; Dr. J. WISHART, *Vice-Chairman*; Dr. J. C. P. MILLER, *Secretary*; Prof. W. G. BICKLEY, Dr. R. O. CASHEN, Prof. R. A. FISHER, F.R.S., Dr. E. T. GOODWIN, Dr. J. HENDERSON, Dr. J. O. IRWIN, Dr. C. W. JONES, Prof. L. M. MILNE-THOMSON, Prof. E. H. NEVILLE, Mr. D. H. SADLER, Mr. F. SANDON, Mr. W. L. STEVENS, Mr. JOHN TODD, Dr. M. V. WILKES, and Mr. J. R. WOMERSLEY.

DURING the past two years, negotiations have been in progress for transferring the responsibility for the work undertaken by the Committee from the British Association to the Royal Society. The Royal Society now has set up a Committee on Mathematical Tables, of which Prof. Bickley, Prof. Fisher, Dr. Miller, Prof. Neville, Mr. Sadler, Dr. Thompson, Dr. Wishart and Mr. Womersley are members. This Committee has set up a General Sub-Committee to advise on and carry out the making and publishing of mathematical tables; an invitation to serve on this Sub-Committee has been extended to other members of the B.A. Committee who are prepared to play an active part in its work.

The assets and liabilities of the B.A. that are associated with the Committee, including the Cunningham Bequest for new tables in the Theory of Numbers, were transferred to the Royal Society on June 30, 1948, and the B.A. Committee held its final meeting on June 23, 1948.

Seven meetings were held in the past year, during which plans were made for continuing the production of tables under the new conditions; the present status of the various projects in hand is given in the list below. Three Volumes, I, VI and IX are to be reprinted shortly, while Volume X has been passed for press. Volume X, Bessel Functions, Part II, will be the final volume in the series of B.A. Mathematical Tables.

Of the grant of £150 available this year, £100 has been spent, on Bessel Function checking and calculations, and on the tables of $\tan^{-1}m/n$, etc. The work of volunteers—in particular, of Mr. D. F. Ferguson, of Mr. C. E. Gwyther, of Dr. H. Gupta and of the Mathematics Division of the National Physical Laboratory, through Mr. Womersley and Dr. Goodwin,—made it unnecessary to spend the full grant this year.

It seems appropriate to include in this final report a short history of the Committee and of its forerunners, with a list of Chairmen and Secretaries. Following this is a list of publications in book form; mathematical tables given in the Committee's reports are listed in *Mathematical Tables and other Aids to Computation*, Volume I, No. 3, 1943 July, pp. 69–75. The report ends with a list of projects at present in hand; the previous report of the Committee, for the period 1939–47, should be consulted for further details of most of these projects.

Short History of the British Association Mathematical Tables Committee

In 1871, at a meeting of the Association in Edinburgh, a Committee was set up, with A. Cayley (served 1871–95) as Chairman (1871–89), J. W. L. Glaisher (1871–1901) as Secretary (1871–89), and H. J. S. Smith (1871–83), G. G. Stokes (1871–84), and Sir W. Thomson, later Lord Kelvin (1871–1901; Chairman, 1897–1901) for its members. The Committee was formed 'for the purpose of reporting on Mathematical Tables, which it may be desirable to compute or reprint.' The first report of the Committee appeared in 1873 when the aims of the Committee were defined more precisely. 'The purposes for which the Committee was appointed were twofold, viz.: (1) to form as complete a catalogue as possible of existing mathematical tables, and (2) to reprint or calculate tables which were necessary for the progress of the mathematical sciences.'

The first task was carried out magnificently in two parts, by Glaisher for general tables in the 1873 report, by Cayley for tables in the Theory of Numbers in 1875. These reports have only been superseded within the last 10 years, and remain bibliographical works of the greatest value.

The second task, the production of new tables, was also commenced immediately and remains in progress. It was at first intended that tables should be published independently of the Annual Reports of the Association, and this was done with Glaisher's table of e^x and e^{-x}, *Trans. Camb. Phil. Soc.*, **13**, 243–272, 1883. The next works prepared and published by the Committee, with James Glaisher added (served 1877–89), were the *Factor Tables for the Fourth, Fifth and Sixth Millions* (published in 1879, 1880, and 1883), which filled the gap between the tables of Burckhardt and of Dase. The publication was financed by grants from the British Association and the Royal Society. The calculations were chiefly the work of James Glaisher, while J. W. L. Glaisher compiled a comparison of the numbers of primes actually counted in various ranges with the numbers given by three different formulæ. The Introduction to the *Sixth Million* contains many similar enumerations of great interest. D. N. Lehmer in his *Factor Table for the First Ten Million*, says of James Glaisher: 'The character of his work should be a matter of the deepest satisfaction to every member of that Association. The sixth million, in particular, is the most remarkable table of the sort ever published. It contains only one slight error in the computation and two insignificant typographical errors!'

In the B.A. Annual Report for 1879 a table of Legendre Polynomials was given, the first of many various functions that appeared in these reports up to 1929.

Other tables initiated during the period 1871–88 by J. W. L. Glaisher, were a Table of Powers of Integers, Tables in the Theory of Numbers connected with the Divisors of a Number, and Tables of the Elliptic Theta Functions. All three reached the stage of printer's proofs, and much mystery is attached to the reasons for not completing the publication at this time. Proof copies of the first two tables were found, and publication, with additions, has recently (1940) been completed in Volumes IX and VIII respectively of the *B.A. Mathematical Tables*. No proof copy of the Elliptic Function tables has come to light and it now seens unlikely that Glaisher's tables will ever be published since they are not in a form that now seems appropriate, and have largely been superseded by the *Smithsonian Elliptic Functions Tables*, by G. W. and R. M. Spenceley.

In 1888 a fresh Committee was set up with Lord Rayleigh as Chairman (1888–97) and A. Lodge (served 1888–1937) as Secretary (1888–96), other new members being A. G. Greenhill (1888–1901, 1910–21), W. M. Hicks (1888–1901) and B. Price (1888–99). The terms of reference were to consider 'The possibility of Calculating Tables of Certain Mathematical Functions, and, if necessary, of taking steps to carry out the calculations, and to publish the results in an accessible form.' This, broadly, has been the task of the Committee ever since, apart from a period of inactivity from 1901 to 1906. At first the attention of the Committee

was directed to the tabulation of Bessel functions, and tables of $I_n(x)$ were given in the report of 1889, $I_1(x)$ in 1893 and $I_0(x)$ in 1896. These were the first of a long series of tables of Bessel functions, culminating in *B.A. Mathematical Tables*, Volume VI, Bessel Functions, Part I, published in 1937, and Volume X, Bessel Functions, Part II, now in the Press, which will terminate the series of *B.A. Mathematical Tables*.

Once again, in 1896, with A. J. C. Cunningham (served 1895–1901) as Secretary (1896–1901), and with P. A. MacMahon (1895–1901) added to the Committee's membership, attention was drawn to a table in the Theory of Numbers, and in 1900 the *Binary Canon*, a new *Canon Arithmeticus*, by A. J. C. Cunningham, was published.

Two other Committees, existing at the same time as the major Committee, may also be considered in some respects as forerunners of the Committee now reporting. When the new Committee was set up in 1888, the old one continued for one year and was then reconstituted for the period 1889–93 with A. Cayley as Chairman, A. Lodge as Secretary, and J. J. Sylvester and A. R. Forsyth as members. Its purpose was to carry on ' the Tables connected with the Pellian Equation from the point where the work was left by Degen in 1817 '; the resulting tables appeared in the Report for 1893. The other Committee (1894–99) was set up ' To co-operate with Prof. Karl Pearson in the Calculation of Certain Integrals.' It had Rev. R. Harley as Chairman, A. R. Forsyth as Secretary, and J. W. L. Glaisher, A. Lodge and K. Pearson as members. Tables connected with the $G(r,\nu)$ or Pearson Integrals, computed under the supervision of this Committee, appeared in 1896 and 1899.

After a lull in activity, the Committee was again set up in 1906, with M. J. M. Hill as Chairman (1906–19), L. N. G. Filon (1906–29) as Secretary (1906–10), and A. Lodge as the only other member, and the sole link, with the old Committees. Its purpose was ' The further tabulation of Bessel Functions ' ; this was altered in 1913 to the ' Calculation of Mathematical Tables,' which has remained the purpose of the Committee since then without a break. A report, dealing with the asymptotic series for $J_n(x)$ and including short tables, was given in 1907. In 1909, the Committee, with the addition of J. W. Nicholson (served 1908–31, Secretary 1910–20, Chairman 1920–31) made a second report, and stated that ' they are also considering the advisability of collecting all existing tables of Bessel Functions and publishing them as a single set of tables in a form easily accessible to all students,' and the following year it was reported that a list of Bessel functions tables had been completed. In 1911 the report dealt with the further tabulation of Bessel and other functions ; A. G. Greenhill, who had rejoined the Committee, also brought forward a scheme for the rearrangement of tables of elliptic functions. In the same report tables of $G_n(x)$ and $Y_n(x)$ by J. R. Airey (1911–37, Secretary 1920–29) were published. During the next few years tables of Bessel functions of various types, and of elliptic functions occupied the attention of the Committee. By 1915 the Committee had become much larger with the addition of A. G. Webster (1912–25), E. W. Hobson (1913–29), A. E. H. Love (1913–31), H. M. Macdonald (1913–30), T. W. Chaundy (1914–28), A. T. Doodson (1915–17 and 1925–31), and H. G. Savidge (1915–16) ; several of the new members had made contributions to the tables of Bessel functions. In the report of this year it was stated, ' the order of calculation is being arranged in accordance with the real urgency of the tables, and the stage is now coming in sight at which the Committee will be able, as authorised already by the Association, to publish a volume of fairly complete tables of the more important transcendental functions.'

In 1916 G. Kennedy (1916–25) and G. B. Mathews (1916–22) joined the Committee, and the report contained tables of sines and cosines of angles in radians (J. R. Airey), logarithmic Gamma function and derivative (G. N. Watson, served 1916–25), Bessel and Neumann functions, etc. (J. R. Airey, A. T. Doodson). Elliptic functions were dealt with in the Report of 1919, and a table, by R. L. Hippisley (1919–23), was given. In 1920 Nicholson became Chairman and Airey Secretary. During the period to 1929 the reports contained tables connected with Bessel functions, Lommel-Weber functions, confluent hypergeometric functions, Fresnel's integrals, hyperbolic sines and cosines, exponential, sine and cosine integrals. During this period, new members of the Committee were R. A. Fisher (1925–48), J. Henderson (1927–48), and Miss D. M. Wrinch (1923–29).

From 1928–31 the Committee was reorganised, E. H. Neville (served 1929–48) becoming Chairman (1931–47), and L. J. Comrie (served 1928–37) becoming Secretary (1929–37). Other new members were J. O. Irwin (1928–48), A. J. Thompson (1928–48), J. F. Tocher (1928–45), T. Whitwell (1928–31), J. Wishart (1928–48, Secretary 1937–46), E. S. Pearson (1930–33) and Frank Robbins (1930–45). In 1928 the decision was made to discontinue the publication of tables in the B.A. Annual Reports, and to give in book form a number of the tables that had appeared in the reports ; gaps were to be filled by new calculations, while provision was to be made for interpolation. The first result of this policy was Volume I in the series of *B.A. Mathematical Tables*, which appeared in 1931. It was edited by J. Henderson

and includes circular and hyperbolic functions, with material from the Reports of 1916, 1923, 1924 and 1928 by Doodson and Airey, collated and completed by Comrie; Exponential, Sine and Cosine Integrals with tables by Airey (from reports of 1927 and 1928) and Fisher, collated by Henderson; Factorial and Polygamma Functions, with tables by Watson (from the 1916 Report), Lodge (1929 Report) and Fisher, collated and completed by Lodge and Wishart; *Hh* functions, or integrals and derivatives of the probability integral, with tables by Airey from the 1928 Report, slightly extended, collated by Irwin, with an account of properties and applications by Fisher. This initiated the period of greatest activity in the Committee's history. The Committee has always owed a great deal to its secretaries. The influence of Glaisher and of Airey, in particular, is well exhibited in the progress of the Committee during their periods of office, while Comrie, by the successful application of commercial machines to the construction of mathematical tables, combined with drive and opportunity to push projects to completion, contributed largely to the rapidity with which the Committee's volumes were produced from 1931 onwards. This, together with particular attention on the part of the Committee to the special typographical problems connected with the printing of numerical tables, and with the emphasis on the needs of the user who may be consulting such tables continuously for long periods, has resulted in standards of accuracy and presentation that have not been surpassed and rarely equalled.

Volume II, Emden Functions, was prepared by D. H. Sadler (served 1932–48), who edited it, and J. C. P. Miller (1933–48, Secretary 1946–48), at the suggestion of Sir Arthur Eddington, and financed jointly by the British Association and the International Astronomical Union. Comrie and Airey were responsible for planning the initial stages of the project, and for devising methods of computation. The resulting volume was published in 1932.

Lt.-Col. A. J. C. Cunningham, who died in 1928, left to Section A of the British Association a legacy for producing new tables in the Theory of Numbers. The duty of making use of this bequest was entrusted to the Committee in 1929, and five volumes coming within its terms have so far been produced. Volume III, published in 1933, gives a table of Minimum Decompositions into Fifth Powers, computed by L. E. Dickson and accepted for publication by the Committee; this is the only volume not produced by printing from type—it was in fact reproduced by photography from typescript—and the results have discouraged a repetition of the experiment, and have reinforced the firm opinion of the Committee that first-class results can be obtained only by printing from type. Volume IV, published in 1934, gives Cycles of Reduced Ideals in Quadratic Fields; this was suggested by W. E. H. Berwick and computed for the Committee by E. L. Ince (served 1932–41). Volume V, published in 1935, is a Factor Table, prepared independently in triplicate by J. Peters, by A. Lodge and Miss E. J. Ternouth, and by Mrs. E. Gifford; the part played by Comrie in collating the three calculations, and in supervising the reading of proofs and the comparisons with published tables was considerable. All three volumes contain the results of new calculations.

The Cunningham Bequest also financed the publication of Volumes VIII, Number-Divisor Tables, and IX, Table of Powers, both of which originated, as remarked above, in tables computed under the direction of J. W. L. Glaisher on behalf of the first Committee about 70 years ago. With proof copies as basis, the tables were checked and extended—Volume VIII, by Prof. D. H. Lehmer (who attended meetings of the Committee by invitation in 1939) and J. Wishart (Editor), and Volume IX by W. G. Bickley, C. E. Gwyther, J. C. P. Miller (Editor), and Miss E. J. Ternmouth. Both volumes were published in 1940.

The production of these volumes has not exhausted the bequest, and further projects connected with the Theory of Numbers have been described in the Committee's previous report. It is intended that these should be completed within the next few years.

In 1929, the decision was taken to separate consideration of Bessel functions from that of other functions, and Bessel functions were made the special business of a sub-committee, whose reports and recommendations have formed the basis of the Committee's subsequent discussions and decisions. The original members of the Sub-Committee were J. Henderson and J. O. Irwin; later members were J. C. P. Miller, D. H. Sadler, A. J. Thompson and W. G. Bickley (served 1934–48), Henderson being Chairman. L. J. Comrie, while Secretary of the main Committee, kept in closest touch with the Sub-Committee and attended many of its meetings. In 1937, Volume VI was published; this is Bessel functions, Part I, (Functions of Order Zero and Unity), and although consisting largely of new calculations, is a result of the continued interest of the Committee since 1888 in Bessel Functions. The volume was dedicated to Prof. Alfred Lodge, secretary of the 1888 Committee, whose record of continuous service is unequalled; Lodge died just before publication, in ignorance of this token of the Committee's appreciation of his work.

The actual preparation of the tables was supervised by Comrie, who also provided an account of the various operations performed and of the final checking of the tables.

Further work on Bessel functions has been subdivided, and the preparation of Part II, (Functions of Integer Order), to form Volume X (and last) of the B.A. Series, has progressed steadily, although much delayed by the war; the calculations have been performed under the supervision of Bickley, Comrie, Miller, Sadler and Thompson. The Bessel Functions Sub-Committee was reappointed this year with W. G. Bickley as Chairman, E. T. Goodwin (who joined the Committee in 1947) as Secretary, and C. W. Jones (who also joined in 1947), J. C. P. Miller, D. H. Sadler and A. J. Thompson as members. It is hoped that this sub-committee will be able to carry forward its plans for further tables of Bessel functions under the Royal Society Committee.

Volume VII, The Probability Integral, by W. F. Sheppard, was published in 1939 as a memorial to Sheppard. It originated in a plan by Sheppard that was not quite complete at his death. It was edited by J. O. Irwin.

The work of the Committee during the period 1928–41 was much accelerated by the employment of paid computers, at first by Comrie when Secretary; later the Committee as a whole employed a full-time computer, who worked at the Galton Laboratory, by invitation of R. A. Fisher, under the supervision of W. L. Stevens (served 1936–48) and D. H. Sadler. The three full-time computers were Mr. F. Cleaver, Dr. H. O. Hartley and Mrs. R. St. H. Tysser; Mrs. Tysser, on resigning the position of computer soon after the outbreak of war, joined the Committee (as Dr. R. O. Cashen (1941–48)). It is hoped that this very successful experiment of employment of a full-time computer may be repeated by the Royal Society Mathematical Tables Committee.

The appearance of Volumes VIII and IX in 1940 was followed by a war-time lull, during which progress was slow, but not negligible. In 1946, a second edition of Volume I appeared, and also two ' Part Volumes ' : A, giving Legendre Polynomials, computed by L. J. Comrie, and edited by A. J. Thompson, and B, giving Tables of the Airy Integral, by J. C. P. Miller, prepared at the suggestion of H. Jeffreys, the work being initiated by L. J. Comrie.

During the period from 1937 onwards, other new members of the Committee were F. Sandon (1938–48), M. V. Wilkes (1938–48), L. M. Milne-Thomson (1939–48), John Todd (1944–48), J. R. Womersley (1944–48).

During the last two years the Committee has been developing the plans outlined in the previous report (for 1939–47) and adding to the list. This report ends with a list of projects in hand and proposed for future work, with an indication of their present status.

The Committee has worked to produce a series of fundamental tables of high accuracy, taking account of practical needs when these were clear, but largely following the inclinations and enthusiasms of its individual members. Its concern has been as much with the technique of table-making as with the results obtained, and it has felt that it was performing a useful function in developing methods and setting standards. If five of the volumes published since 1931 are connected with the Theory of Numbers, this is because the Cunningham Bequest made them possible; examination of the list of projects in hand will show that the Committee's interests have been wide and that the tables ultimately to be published will combine with earlier ones to form a well-balanced set.

In preparing tables for publication and in seeing them through the press, the main aims of the Committee may be summarised as follows: complete accuracy within stated limits (*e.g.*, within 0·52 of the last digit given), full provision for interpolation wherever feasible and relevant, and the highest standards of typography and arrangement. These have been the occasion of numerous and lengthy discussions in Committee, and the standards attained have not been surpassed. New devices of great power for interpolation have been introduced—in particular, modified differences in Volume I, with extended use in Part-Volume B.

Chairmen.	*Secretaries.*
A. Cayley, 1871–89.	J. W. L. Glaisher, 1871–89.
Lord Rayleigh, 1888–97.	A. Lodge, 1888–96.
*A. Cayley, 1889–93.	*A. Lodge, 1889–93.
†Rev. R. Harley, 1894–99.	†A. R. Forsyth, 1894–99.
Lord Kelvin, 1897–1901.	A. J. C. Cunningham, 1896–1901.
M. J. M. Hill, 1906–19.	L. N. G. Filon, 1906–10.
J. W. Nicholson, 1920–31.	J. W. Nicholson, 1910–20.
E. H. Neville, 1931–47.	J. R. Airey, 1920–29.
A. J. Thompson, 1947–48.	L. J. Comrie, 1929–37.
	J. Wishart, 1937–46.
	J. C. P. Miller, 1946–48.

* Pellian Equation Committee.

† Pearson Integrals Committee.

B.A. MATHEMATICAL TABLES COMMITTEE

Separate Publications

Factor Table for the Fourth Million. By James Glaisher. 52 + 112 pp., 1879.
Factor Table for the Fifth Million. By James Glaisher. 12 + 112 pp., 1880.
Factor Table for the Sixth Million. By James Glaisher. 106 + 112 pp., 1883.
A Binary Canon. By A. J. C. Cunningham. viii + 172 pp., 1900.

B.A Mathematical Tables.

Vol. I. (1st Edition). Circular and Hyperbolic Functions, Exponential, Sine and Cosine Integrals, Factorial (Gamma) and Derived Functions, Integrals of Probability Integral. xxxvi + 72 pp. London, B.A. Office, 1931.

Vol. I. (2nd Edition). Circular and Hyperbolic Functions, Exponential, Sine and Cosine Integrals, Factorial Function and Allied Functions, Hermitian Probability Functions. xii + 72 pp. Cambridge University Press, 1946.

Vol. II. Emden Functions. By D. H. Sadler and J. C. P. Miller. viii + 34 pp. London, B.A. Office, 1932.

Vol. III. Minimum Decompositions into Fifth Powers. By L. E. Dickson. vi + 370 pp. London, B.A. Office, 1933.

Vol. IV. Cycles of Reduced Ideals in Quadratic Fields. By E. L. Ince. xvi + 80 pp. London, B.A. Office, 1934.

Vol. V. Factor Table, giving the Complete Decomposition of all numbers less than 100,000. By J. Peters, A. Lodge and E. J. Ternouth, E. Gifford; collated and edited by L. J. Comrie. xvi + 292 pp. London, B.A. Office, 1935.

Vol. VI. Bessel Functions, Pt. I, Functions of Orders Zero and Unity. Edited by J. Henderson, tables compiled and described by L. J. Comrie. xx + 288 pp. Cambridge University Press, 1937.

Vol. VII. The Probability Integral. By W. F. Sheppard. Edited by J. O. Irwin. xii + 34 pp. Cambridge University Press, 1939.

Vol. VIII. Number-Divisor Tables. By J. W. L. Glaisher. Completed by D. H. Lehmer and J. Wishart (Editor). x + 100 pp. Cambridge University Press, 1940.

Vol. IX. Table of Powers, giving Integral Powers of Integers. By J. W. L. Glaisher, W. G. Bickley, C. E. Gwyther, J. C. P. Miller (Editor), E. J. Ternouth. xii + 132 pp. Cambridge University Press, 1940.

Pt.-Vol. A. Legendre Polynomials. By L. J. Comrie. Edited by A. J. Thompson. 42 pp. Cambridge University Press, 1946.

Pt.-Vol. B. The Airy Integral. By J. C. P. Miller. 56 pp. Cambridge University Press, 1946.

Auxiliary Tables (on card), prepared by J. C. P. Miller.
Number 1. Coefficients in the Modified Everett Interpolation Formula, 1946.
Number 2. Table for Interpolation with Reduced Derivatives, 1946.

In the Press.

Vol. X. Bessel Functions, Part II, Functions of Positive Integer Order 2 to 20. By W. G. Bickley, L. J. Comrie, J. C. P. Miller, D. H. Sadler, A. J. Thompson. About 300 pp.

Vols. I, VI, IX. Further editions or reprints are in process of preparation.

PROJECTS IN HAND, FOR FUTURE CONSIDERATION BY THE ROYAL SOCIETY MATHEMATICAL TABLES COMMITTEE.

Most of these projects have already been described fairly fully in the 1939–47 report of the Committee, and will only be noted briefly below. Numbers 1, 3, 5 and 8 are to be published by means of the Cunningham Bequest and are expected to exhaust it.

Tables completely or almost completely planned, and for which considerable work has been done.

1. *The Farey Series*, F_{1025}. Compiled and edited by Prof. E. H. Neville. See previous report. Manuscript and preliminaries complete. About 420 pp.
2. *Bessel Functions of Orders* $\pm\frac{1}{4}$ and $\pm\frac{3}{4}$. Initiated by Dr. L. J. Comrie, edited by Mr. D. H. Sadler. See previous report. Computations almost completed.

3. *Binomial Coefficients.* The origin of this project is the Table of Binomial Coefficients offered by Mr. W. E. Mansell and mentioned in the last report. A pagination scheme has been drawn up, and the preparation of new material and of printer's copy is in progress.

4. *Fundamental Tables of Bessel Functions to many decimal places.* This includes the extension of Meissel's table of $J_n(x)$ mentioned in the previous report. Computations by Mr. C. E. Gwyther and Dr. J. C. P. Miller have reached an advanced stage. The N.P.L. Mathematics Division is assisting with final stages in the calculations.

5. *Partition Tables.* By Prof. H. Gupta, with extensions by Mr. C. E. Gwyther and Dr. J. C. P. Miller. See previous report. Prof. Gupta has extended his table for $m \leqslant 50$ to $n = 400$, and has offered to prepare copy for the printer. A pagination scheme has been prepared.

6. *Cartesian to Polar Conversion Tables.* Supervised by Prof. E. H. Neville. To give, for integral values of x, y, with $y \leqslant x \leqslant 105$, values to 12 figures of r with θ in degrees and of $\ln r$ with θ in radians. Values of r not hitherto available are being computed at the Mathematics Division of the N.P.L., and values of θ by Mr. S. Johnston and others; the table incorporates unpublished results by Miss E. J. Ternouth and Mr. S. Johnston.

Tables agreed by the Committee, at least in principle, and for which considerable work has been done.

7. *Bessel Function Zeros.* Supervised by Prof. W. G. Bickley, Dr. C. W. Jones and Dr. J. C. P. Miller. See previous report.

8. *Coefficients in Powers of Euler's product.* $F(q) = \prod_{k=1}^{\infty} (1 - q^k)$. See previous report. Computations in progress by Mr. D. F. Ferguson and Dr. J. C. P. Miller. It is also proposed to give coefficients in powers of $F(q)F(q^2)$, of $F(q)F(q^3)$, etc.

Projects on which some work has been done, but which have not reached the stage of formal adoption.

9. *Bessel Functions of half-integer order.* Values calculated for I_n and K_n under the supervision of Dr. J. C. P. Miller are offered by Scientific Computing Service. Extension of these tables is in hand under the supervision of Dr. C. W. Jones.

10. *Fundamental Tables for Computers to many figures.* Supervised by Dr. A. J. Thompson. It is proposed to produce a collection giving short tables of functions, mainly elementary, and of constants to a high degree of accuracy. These are intended to meet the occasional needs of computers of mathematical tables who want certain fundamental values to many figures. Members of the Committee have already made contributions; readers who possess suitable material that they are willing to make available are invited to offer them to the Committee.

    Considerable progress has been made with tables of square roots (50 decimals), cube roots (20 decimals), fourth and twelfth roots, by Mr. D. F. Ferguson, Mr. C. E. Gwyther, Mr. S. Johnston and Dr. J. C. P. Miller; with a table of $\log_{10} N$ to 45 decimals and with a table of $\log \Gamma(x)$ to 32 decimals by Dr. A. J. Thompson. A table of $n!$ to $n = 1000$, with 20 figures has also been offered by Mr. S. Johnston.

11. *Confluent Hypergeometric Functions.* Computed by Dr. A. J. Thompson. See last report.

12. *Struve Functions.* Tables have been prepared by Mr. C. Robinson at King's College, London, for an M.Sc. Thesis, under the general supervision of Dr. J. C. P. Miller. These need extension and subtabulation.

Possible Future Projects.

13. *Kelvin Functions.* A programme of computation is under consideration by Mr. G. A. Garreau, Mr. M. Bridger and Mr. G. K. Vincent of Northampton Polytechnic, St. John St., London, E.C.1.

14. *Integrals of Bessel Functions.* The computation of a number of these is under consideration by Dr. E. T. Goodwin.

15. *Inverse Tangents.* A large number of inverse tangents in radians have been computed, some in the preparation of the Cartesian to Polar Conversion Tables (No. 6) and some for other purposes. The publication of a systematic collection of these tables, as a supplement to No. 6 or otherwise, is under consideration.

BRIGHTON MEETING: 1948
SECTIONAL TRANSACTIONS

Any references to publication supplied by authors will be found on page 353.

SECTION A

MATHEMATICS AND PHYSICS

September 9

SYMPOSIUM on *The physics of coastal waves.*

Dr. G. E. R. Deacon, F.R.S.—*Properties of coastal waves.*

Mr. N. F. Barber.—*Theories of coastal waves.*

Brig. R. A. Bagnold, O.B.E., F.R.S.—*Movement of sand by waves.*

Major W. W. Williams.—*Interaction of waves and beaches.*

SYMPOSIUM on *Cosmic magnetism.*

Prof. S. Chapman, F.R.S.—*The terrestrial, solar and stellar magnetic fields.*

Dr. Georg Thiessen.—*Visual measurement of the general magnetic field of the sun.*

Mr. S. R. Runcorn.—*Magnetic measurements in mines, and the origin of the earth's field.*

September 10

PRESIDENTIAL ADDRESS by Sir Lawrence Bragg, O.B.E., F.R.S., on *Recent advances in the study of the crystalline state.*

Prof. W. G. Burgers.—*Twins in recrystallized metals.*

Mrs. D. Hodgkin, F.R.S.—*Structure of penicillin.*

Mrs. K. Lonsdale, F.R.S.—*Movements of atoms in crystals.*

Dr. M. F. Perutz.—*The structure of some crystalline proteins.*

September 13

SYMPOSIUM on *Magnetism.*

Mr. D. A. Oliver.—*Recent advances in anisotropic permanent magnet alloys.*

Mr. N. F. Astbury.—*Anisotropic silicon iron.*

Dr. D. Shoenberg.—*Magnetic properties of superconductors.*

September 14

SYMPOSIUM on *Instrumentation and control, including industrial applications of electronic devices.*

Sir Ewart Smith.—*The contribution of instrumentation to industrial progress.*

Mr. S. S. Carlisle.—*The use of electronic devices in the iron and steel industries.*

Prof. K. A. Hayes.—*Servo-mechanisms.*

Dr. A. M. Uttley.—*Recent work on photo-electric servo-mechanisms.*

Dr. D. Gabor.—*Microscopy by wave-front reconstruction.*

SUB-SECTION A*

MATHEMATICS

September 9

Dr. D. Pedoe.—*Some important ideas in modern algebraic geometry.*

Prof. E. H. Neville.—*Elementary uses of Farey Series.*

September 10

Dr. G. J. Whitrow.—*Relativity and the scale of time: a survey of some recent developments in cosmology and natural philosophy.*

September 13

JOINT DISCUSSION with Section G (Engineering) on *Application of statistics in engineering.* (*See entry under Section G.*)

September 14

JOINT DISCUSSION with Section G (Engineering) on *Applicable Mathematics.* (*See entry under Section G.*)

SECTION B

CHEMISTRY

September 9

JOINT DISCUSSION with Section M (Agriculture) on *Maintenance of the world food supply.* (*See entry under Section M, Agriculture.*)

September 10

SYMPOSIUM on *Newer metals and alloys in industry.*

Dr. C. H. Desch, F.R.S.—*General introduction.*

Mr. R. Eborall—*Non-ferrous metals and alloys.*

Mr. D. A. Oliver.—*Magnetic alloys.*

Dr. L. B. Pfeil.—*Heat-resisting alloys.*

Dr. J. C. Chaston.—*Rare and precious metals and alloys.*

September 13

PRESIDENTIAL ADDRESS by Prof. John Read, F.R.S., on *Specialisation and culture in chemistry.*

DISCUSSION on *Conservation of the chemical elements,* opened by Prof. J. D. Bernal, F.R.S., with contributions by Dr. R. P. Linstead, C.B.E., F.R.S., Dr. R. Lessing, Dr. B. A. Southgate, and others.

September 14

SYMPOSIUM on *Building materials with special reference to new materials.*

Dr. F. M. Lea, O.B.E.—*Some modern trends in building materials.*

Mr. E. I. Brimelow.—*The use of aluminium alloys in building.*

Dr. T. W. Parker.—*Lightweight building materials.*

Mr. R. J. Schaffer.—*The use of plastics in building.*

SECTION C

GEOLOGY

September 9

Dr. J. F. Kirkaldy.—*The geology of the Brighton district.*

Rev. J. W. Reeves.—*The thickness variations of the Wealden beds of the southern Weald.*

Mr. P. A. Ongley.—*Investigations into Dowsing and the use of the divining rod.*

September 10

DISCUSSION on *Geology and air photography.*
Dr. H. Hamshaw Thomas, M.B.E., F.R.S.—*Some characteristics of air photographs.*
Mr. P. G. Mott.—*Aerial photogrammetric survey applied to geological mapping.*
Mr. P. Evans.—*Photogeology as a stage in mapping.*
Prof. D. L. Linton.—*The geological uses of photo-interpretation.*

September 13

PRESIDENTIAL ADDRESS by Dr. A. E. Trueman, F.R.S., on *Geology to-day and to-morrow.*
DISCUSSION on *The training of the geologist.*
Prof. T. N. George.—*University courses.*
Prof. H. H. Read, F.R.S.—*Training in geological research.*
Mr. P. Evans.—*The geologist in industry.*

September 14

JOINT DISCUSSION with Section E (Geography) on *The denudation of the Weald.* (*See entry under Section E.*)

September 15

Mr. M. V. N. Murthy and Mr. M. S. Rao.—*Composite intrusions from Arran.*
Mr. D. L. Searle.—*The Dyke Swarm of Southern Jersey.*
Dr. A. T. J. Dollar.—*Some glacial features of Jan Mayen Island.*

SECTION D

ZOOLOGY

September 9

PRESIDENTIAL ADDRESS by Prof. H. Graham Cannon, F.R.S., on *Undergraduate zoology.*
PAPERS on *Functional morphology.*
Prof. Alastair Graham.—*The molluscan stomach.*
Mr. J. E. Smith.—*The architecture and activities of the starfish tube-foot.*
Mr. G. P. Wells.—*Morphology and movements of* Arenicola marina *L.*
Miss E. J. Batham.—*Neuro-muscular system of Metridium.*
Dr. Gordon Newell.—*Burrowing and crawling of worms.*
Prof. H. Graham Cannon, F.R.S.—*The anatomy of the barnacle.*

September 10

PAPERS on *Biological aspects of colonial development.*
Sir Frank Stockdale, G.C.M.G.—*Some biological aspects of colonial development.*
Mr. A. J. Wakefield, C.M.G.—*The groundnut scheme.*
Dr. R. Rainey.—*Pest problems of cotton-growing in Africa.*
Dr. C. F. Hickling.—*Colonial fisheries.*
Dr. E. Trewavas.—*Systemic zoology and fisheries.*
Dr. N. A. Mackintosh.—*The stock of whales in relation to the Colonies.*
Miss R. Lowe.—*Problems in the ecology of the fresh-water fish and fisheries of Central Africa.*

September 13

PAPERS on *British Marine Fisheries.*
Dr. Michael Graham.—*The theory of fishing.*
Mr. E. Ford.—*The individual in fishing and fisheries research.*
Mr. G. A. Steven.—*The mackerel; new light on its migrations and habits.*
Prof. J. E. G. Raymont.—*Fertilisation of marine areas.*
Mr. A. R. Margetts and Mr. S. J. Holt.—*Effects of the war on North Sea fish.*
Dr. R. J. Pumphrey.—*The distribution of colour perception in the animal kingdom.*
Dr. R. W. Pickford.—*Varieties of colour vision in Man.*
Dr. M. G. M. Pryor.—*The nature of animal coloration.*
Dr. G. S. Carter.—*The biology of colour vision.*
See also under Section H for session on *Human blood groups.*

September 14

JOINT SESSION with Section K (Botany) on *The place of biology in the educational curriculum.*
Prof. H. Graham Cannon, F.R.S.
Dr. L. M. J. Kramer.—*Some aspects of sixth form biology.*
Mr. H. J. Bonham.—*Modern school biology.*
Prof. T. M. Harris, F.R.S.—*Interim report of the Joint Committee on the Teaching of Biology.*
General Discussion.
Mr. Peter Scott.—*Wildfowl.*

SECTION E

GEOGRAPHY

September 9

PAPERS on *The historical geography of Sussex.*
Dr. S. H. King.—*Aspects of the historical geography of Sussex in the early middle ages.*
Miss G. J. Fuller.—*Development of roads through the Weald to the Sussex coast in the 18th and 19th centuries.*
Mr. W. H. Parker.—*The effect of the railway and motor car upon the distribution of population in Sussex.*
Mr. E. W. Gilbert.—*The growth of Brighton.*

September 10

PRESIDENTIAL ADDRESS by the Rt. Hon. Lord Rennell of Rodd, K.B.E., C.B. on *Geography as a social science with a special reference to Africa.*
DISCUSSION on *Scientific aspects of colonial development.*
Speakers included: Mr. R. W. Steel, Dr. R. J. H. Church, Mr. E. Paget and Mr. B. H. Farmer.
Dr. F. J. Fowler.—*The canal colonies of the Punjab: a pioneer zone of agricultural settlement.*
Mr. A. McL. Frood.—*Post-war economic developments in Egypt.*

September 13

JOINT DISCUSSION with Section H (Anthropology) on *Movements of Population in the Commonwealth.*
Speakers included: Prof. C. B. Fawcett, Prof. Brinley Thomas, Mr. R. R. Rawson, Mr. G. I. Jones and Dr. E. R. Leach.
Mr. W. Smith.—*Mobility in the location of industry in Great Britain.*
Dr. A. N. Harris.—*The geomorphology of north-east Wales.*
Mr. J. M. Mogey.—*Ballydun, a study of the Ulster town.*

September 14

JOINT DISCUSSION with Section C (Geology) on *The denudation of the Weald.*
Chairman: Dr. A. E. Trueman, F.R.S.
Prof. S. W. Wooldridge.—*The problem of slope formation within the Weald, with special reference to the Lower Greensand Escarpment.*

Dr. A. J. Bull.—*Nivation in South Downs.*
Dr. J. F. Kirkaldy.—*A summary of the evidence of the Wealden river profiles.*
Mr. B. W. Sparks.—*Erosion levels in the South Downs.*
Prof. D. L. Linton and Prof. A. A. Miller also spoke.
Mr. F. W. Morgan.—*The pre-war hinterlands of the German Baltic ports.*
Prof. Joseph E. Williams.—*Chemical weathering at low temperatures.*

SECTION F

Economics and Statistics

September 9

Prof. I. Bowen.—*Building materials supply.*
Mr. S. R. Dennison.—*Industrial productivity.*
Mr. J. C. Picton.—*Administration of large-scale enterprises.*

September 10

Presidential Address by Prof. Sir Hubert D. Henderson, on *The price system.*
Prof. A. J. Brown.—*Some aspects of inflation.*
Mr. R. C. Tress.—*The diagrammatic representation of national income flows.*

September 13

Mr. F. W. Paish.—*Capital investment.*
Prof. J. Sykes.—*Distribution of Industry Act and the Development Areas.*
Mr. A. M. Henderson.—*Public enterprise profits and chargings.*
Mr. D. C. Hague.—*Contribution of economic analysis to the understanding of business behaviour.*

September 14

Symposium on Food.
Miss R. Cohen.—*Economics factors affecting food supply.*
Mr. J. H. Davies.—*Bulk purchase.*

SECTION G

Engineering

September 9

Presidential Address by Wg.-Comm. T. R. Cave-Browne-Cave, C.B.E., on *The young engineer.*
Discussion on the Presidential Address.
Mr. J. G. G. Hempson.—*An engineer's problems in the measurement of stress and pressure.*

September 10

Mr. O. V. S. Bulleid.—*Railway locomotive developments.*
Discussion on *The metric system—arguments for and against its universal adoption.*
Speakers: Mr. P. Good, C.B.E., Dr. L. Hartshorn, Mr. P. Johnson, Dr. H. S. Rowell, O.B.E.

September 13

Joint Discussion with Sub-Section A* (Mathematics) on *The application of statistics in engineering.*
Dr. B. P. Dudding, M.B.E. and Mr. W. J. Jennett.—*Statistical methods and engineering processes.*
Mr. A. W. Swan.—*Production Statistical Control in heavy industry.*
Mr. D. J. Desmond.—*The accuracy of automatic lathes.*
Prof. G. A. Barnard.—*The design of a sampling inspection scheme.*
Mr. E. C. Fieller.—*Statistical aspects of specification.*
Prof. S. J. Davies and Mr. F. G. Watts.—*Fuel and power economy, with special reference to heat pumps.*

September 14

Sir Harry R. Ricardo, F.R.S.—*Diesel Engines.*
Joint Discussion with Sub-Section A* (Mathematics) on *Applicable mathematics.*
Opening Speakers included: Mr. D. N. de G. Allen, Dr. J. A. Pope, Mr. F. S. Snow, Dr. G. G. McFarlane. Concluding speaker: Prof. W. G. Bickley.

SECTION H

Anthropology and Archaeology

September 9

Presidential Address by Mr. R. U. Sayce, on *Folk-life studies in Britain and abroad.*
Canon J. A. MacCulloch.—*Folk-memory in folk-tales.*
Mr. D. N. Kennedy.—*Dance magic in England.*
Dr. K. P. Oakley.—*Application of the fluorine test to the Galley Hill skeleton.*
Prof. W. E. Le Gros Clark, F.R.S.—*Fossil apes collected by the British-Kenya Miocene Expedition, 1947.*
Mr. A. L. Armstrong.—*Excavations in palaeolithic rock-shelters of the Creswell group, and the discovery of a human skull.*

September 10

Discussion on *Primitive techniques and their influence on economic organisation.*
Mr. A. Digby.—*The relation between techniques and economic organisation among primitive peoples, and the importance of the time factor.*
Mr. G. I. Jones.—*The people of the Big Hoes: a study of the Ogukw Ibo tribes with special reference to the correlation between their agricultural technique and their social structure.*
Prof. J. H. Hutton, C.I.E.—*A brief comparison between dry and irrigated cultivation economies in the Naga hills, and the effect of change from the former to the latter.*
Dr. E. R. Leach.—*Some aspects of shifting dry rice cultivation in North Burma and British Borneo.*
Discussion on *Early agriculture.*
Mr. F. G. Payne.—*Plough type and field shape.*
Dr. E. C. Curwen.—*The development of the north-west European sickle.*
Mr. G. A. Holleyman.—*The rise and decline of the Celtic field system in Sussex.*

September 13

Mr. L. F. Henriques.—*Pocomania, a Jamaica cult.*
Dr. M. Gluckman.—*The concept of the reasonable man in Barotse law.*
Dr. J. G. Peristiany.—*The individual in Durkheimian society.*
Prof. R. A. Cordingley.—*A scheme for the investigation of English rural dwelling types.*
M. Marcel Maget.—*Regional types of houses in France.*

JOINT DISCUSSION with Sections D (Zoology) and I (Physiology) on *Human blood groups.*

Dr. J. A. Fraser Roberts.—*Blood groups and human genetics.*

Dr. R. R. Race.—*The multiplicity of blood groups in man.*

Dr. C. D. Darlington, F.R.S.—*Blood groups and language.*

Dr. A. E. Mourant.—*The ethnological distribution of Rh and MN blood groups.*

Dr. P. L. Mollison.—*Haemolytic disease of the new-born.*

September 14

Mr. Seton Lloyd.—*Two seasons' excavating at Eridu, Mesopotamia.*

Bey Ahmet Dönmez and Mr. W. C. Brice.—*The distribution of some varieties of early pottery in S.E. Turkey.*

Prof. P. E. Newberry, O.B.E.—*Was the Delta or Upper Egypt the home of the predynastic civilisation of Egypt?*

Dr. R. F. Fortune.—*Sir James Frazer's theory of primitive warfare.*

Mr. J. D. Freeman.—*The Fono Manu of Sa'anapu, Western Samoa.*

SECTION I

PHYSIOLOGY

September 9

DISCUSSION on *The changing aspects of nutrition.*

Prof. J. R. Marrack.—*Problem of nutrition in relation to resistance to infection.*

Prof. A. Fleisch.—*Minimal sufficient nutrition.*

Prof. B. S. Platt.—(a) *The ramifications of the problem of nutrition in an African community.*

(b) *An experiment in the improvement of nutrition in an African village.*

Dr. J. W. Howie.—*Nutrition and resistance to infection.*

DISCUSSION on *Transmission of effects from the endings of nerve fibres.*

Sir Henry Dale, O.M., G.B.E., F.R.S.—*Introduction.*

Prof. F. R. Miller, F.R.S. *Local actions of eserine and acetylcholine on the central nervous system.*

Dr. W. Feldberg.—*Problems of synaptic transmission.*

Dr. J. W. Pringle and Dr. G. M. Hughes.—*Differential facilitation of antagonistic reflexes in Arthropods.*

September 10

JOINT DISCUSSION with Section J (Psychology) on *Problems of old age.*

Sir E. Rock Carling.—*Introduction.*

Dr. Marjory Warren.—*The medical care and rehabilitation of elderly people.*

Dr. W. A. Sanderson.—*Old age as a social problem.*

Mr. A. T. Welford.—*Psychological aspects of the problems of old age.*

Mrs. Barbara Lewis.—*The economic implications of an ageing population.*

September 13

DISCUSSION *on Colour vision.*

PRESIDENTIAL ADDRESS by Prof. H. Hartridge, F.R.S., on *Recent advances in colour vision.*

Dr. Katharine Tansley.—*Retinal sensitivity to different wavelengths.*

Dr. W. D. Wright.—*The interpretation of colour mixture data.*

See also under Section H for session on *Human blood groups.*

September 14

JOINT DISCUSSION with Section M (Agriculture) on the *Physiology of lactation.*

Prof. H. D. Kay, C.B.E., F.R.S.—*Some aspects of the bio-chemistry of milk secretion.*

Dr. S. J. Folley.—*Endocrine and nervous control of lactation.*

Dr. K. C. Richardson.—*Cytology and anatomy of mammary gland.*

Dr. K. L. Blaxter.—*Practical aspects and implications of endocrine treatment of dairy cattle.*

Dr. F. W. Gairns.—*Possible nervous factors in suckling.*

SECTION J

PSYCHOLOGY

September 9

Dr. R. W. Pickford.—*Race and colour vision.*

Dr. L. G. Fuchs.—*Training methods for the partially sighted.*

Dr. H. J. Eysenck.—*Psychology of anti-semitism.*

PRESIDENTIAL ADDRESS by Prof. A. Rex Knight, on *Present-day trends in British psychology.*

September 10

JOINT DISCUSSION with Section I (Physiology) on *Problems of old age.* (*See entry under Section I.*)

Miss M. D. Vernon.—*The development of imaginative construction in children.*

DISCUSSION on *The adolescent and the cinema.*

Mr. N. D. Dodman.—*Cinema attendance among adolescents.*

Miss B. Kesterton.—*The content of films seen by adolescents.*

Mr. W. A. Simson.—*The social and emotional effects of films on adolescents.*

September 13

Prof. T. H. Pear.—*The relations between anthropology, psychology and sociology.*

Mr. H. S. Williams.—*The development of guidance in Australia.*

Mr. P. A. D. Gardner.—*Psychological characteristics of peptic ulcer patients.*

Mrs. F. M. Austin.—*Psychological control of fear.*

Dr. E. A. Peel.—*Some problems involved in the use of the objective test as a measuring device.*

Miss D. M. Lampard.—*The relationship between levels of reading comprehension and word recognition in secondary modern pupils.*

Dr. P. E. Vernon.—*An investigation of post-war reading ability.*

September 14

DISCUSSION on *The nature of incentives.*

Speakers included: Mr. N. Balchin, Prof. C. A. Mace, Mr. A. Curle and Mr. A. Rodger.

Mr. B. S. Morris.—*Some concepts and techniques relating to problems of social change.*

Dr. E. Jaques.—*Interpretative group discussion as a method of facilitating social change.*

Dr. E. O. Mercer.—*Background studies in selection for high-grade appointments.*

Mr. A. Gilbert.—*New-type examinations in technical education.*

SECTION K

BOTANY

September 9

DISCUSSION on *National Forest Parks.* Opening Speaker : Prof. J. Walton.

Dr. J. Ramsbottom.—*Kodachromes of British fungi.*

PRESIDENTIAL ADDRESS by Prof. J. R. Matthews on *The study of the British flora.*

Prof. R. Heim.—*Evolutionary life-history of Termitomyces.*

Dr. Malcolm Wilson and Mr. M. C. Das.—*The life-history of Ginanniella primulae and of G. trientalis.*

Mr. D. M. Henderson.—*The life-history of Sclerotinia tuberosa.*

Dr. J. Macdonald.—*The living mycelia of some Basidiomycetes.*

September 10

JOINT DISCUSION with Sections D (Zoology) and M (Agriculture) on *Inbreeding and hybrid vigour in livestock and crop improvement.* (*See entry under Section M.*)

Prof. J. Walton.—*The morphology of Equisetalean strobili.*

Dr. Paul Richards.—*Vegetation of Cameroons mountain.*

Prof. R. D'O. Good and Miss M. M. Hyde.—*Evolution and the flowering plants.*

Miss Sheila M. Robb.—*Observations on the sporogonium of Pellia epiphylla.*

JOINT MEETING with Sub-section K* (Forestry). (*See entry under K**.)

September 13

SYMPOSIUM on *Genetical structure of plant populations.*

Dr. W. B. Turrill.—*The genetical structure of plant populations in relation to geographical and ecological distributions.*

Mr. J. L. Crosby.—*Intrapopulation heterogeneity and the breeding range of the individual plant.*

Dr. A. J. Bateman.—*The structure of populations of cultivated plants.*

Dr. H. G. Baker.—*Gene-flow between inter-fertile species.*

Dr. D. H. Valentine.—*Interspecific hybridisation in Primulas.*

JOINT DISCUSSION with Sub-section K* (Forestry) on *Coppice management.* (*See entry under K**.)

Dr. George Taylor.—*Plant hunting in Tibet.*

September 14

JOINT DISCUSSION with Section D (Zoology) on *The place of biology in the educational curriculum.* (*See entry under Section D.*)

SUB-SECTION K*

FORESTRY

September 9

DISCUSSION on *Forestry Education.*

Opened by Prof. E. C. Mobbs.

Mr. J. M. B. Brown.—*Beech cultivation.*

Mr. J. Rishbeth.—*Fomes annosus on pines in East Anglia.*

September 10

JOINT DISCUSSION with Sections D (Zoology), K (Botany), and M (Agriculture) on *Inbreeding and hybrid vigour in livestock and crop improvement.* (*See entry under Section M.*)

CHAIRMAN'S ADDRESS by Mr. W. L. Taylor, C.B.E., on *The influence of forestry on the community.* Followed by discussion : Prof. F. T. Brooks, C.B.E., F.R.S., Mr. A. H. Gosling and Mr. O. J. Sangar.

SEPTEMBER 13

Mr. T. R. Peace.—*Poplar and poplar cultivation.*

Mr. James MacDonald.

JOINT DISCUSSION with Section K (Botany) on *Coppice management.*

Speakers included : Col. H. S. Eeles, O.B.E. and Mr. A. L. Felton.

Mr. F. K. Makins.—*Underwood in the south-west.*

SECTION L

EDUCATION

September 9

DISCUSSION on *Aspects of world education.*

Dr. W. P. Alexander and Mr. R. Gould on *Unesco.*

Mr. John Trevelyan.—*British Families Education Service in Germany.*

September 10

PRESIDENTIAL ADDRESS by Mr. W. O. Lester Smith, C.B.E., on *The changing scope of education.*

DISCUSSION on *Administration and teacher.*

Opening Speakers : Mr. L. R. Buckley and Sir Fred Clarke.

September 13

DISCUSSION on *The young worker in industry.*

Sir Arthur Fleming, C.B.E., Mr. K. R. Evans and Mr. D. J. Crowther.—*Progress in industrial education and training during the war period.*

Mr. F. Bray.—*The young worker in industry.*

Dr. A. F. H. Ward.—*Scientific research in Universities and Technical Colleges.*

Mr. R. Birley.—*Reconstruction of education in Germany.*

Mr. R. Beloe.—*Visual aids to education.*

September 14

DISCUSSION on *Selection at the University level.*

Opening Speakers : Mr. J. O. Roach, Mrs. J. L. Stocks and Mr. C. R. Morris.

SECTION M

AGRICULTURE

September 9

JOINT DISCUSSION with Section B (Chemistry) on *Maintenance of the world food supply.*

PRESIDENTIAL ADDRESS by Dr. G. Scott Robertson on *Agriculture and the world food problem.*[1]

Sir John Russell, O.B.E., F.R.S.—*Our part in the world food problem.*

Prof. T. P. Hilditch, F.R.S.—*World fat supplies in relation to the needs of Great Britain and the Commonwealth.*

[1] Read by Prof. H. G. Baskett in the unavoidable absence of the author.

September 10

JOINT DISCUSSION with Sections D (Zoology) and K (Botany) on *Inbreeding and hybrid vigour in livestock and crop improvement.*

Dr. J. M. Rasmusson.—*Inbreeding and hybrid vigour in the improvement of Swedish sugar beet.*

Prof. R. A. Fisher, F.R.S.—*Theory of inbreeding.*

Mr. G. M. L. Haskell.—*Hybrid maize.*

Dr. K. Mather.—*Genetical considerations in the utilisation of hybrid vigour.*

Dr. H. P. Donald.—*Inbreeding and cross breeding in livestock.*

September 13

DISCUSSION on *Control of environment in horticulture.*

Dr. W. F. Bewley.—*The control of heat and light in glasshouses.*

Mr. R. Bush.—*Frost and the fruitgrower.*

Mr. F. A. Secrett, C.B.E.—*Horticultural crops in their relationship to water.*

September 14

JOINT DISCUSSION with Section I (Physiology) on *The physiology of lactation.* (*See entry under Section I.*)

REFERENCES TO PUBLICATION OF COMMUNICATIONS TO THE SECTIONS

AND OTHER REFERENCES SUPPLIED BY AUTHORS

(As at Jan. 1, 1949)

The titles of discussions, or the name of readers of papers in the Sections, as to which publication notes have been supplied, are given below in alphabetical order under each Section.

References indicated by 'cf.' are to appropriate works quoted by the authors of papers, not to the papers themselves.

General reference may be made to the issues of *Nature* from September 1948 onwards and to the supplement to *Discovery*, October 1948.

SECTION A

Symposium on 'Instrumentation and control,' 1948 *Nature*, **162,** 761

Symposium on 'Magnetism,' 1948 *Nature*, **162,** 799.

Symposium on 'The physics of coastal waves,' 1948 *Nature*, **162,** 682.

Bagnold, Brig. R. A. Cf. *J. Inst. Civil Engineers*, Nov. 1940; *Ibid.*, Feb. 1948; 1946 *Proc. Roy. Soc.* **187**; 1947 *J. Geol. Soc.*, **103,** Part 2.

Burgers, Prof. W. G. Cf. 'Forme des cristaux et vitesse de croissance lors de la recristallisation de l'aluminium,' 1947 *J. de Chimie Physique*, **44,** 292–295; 'Growth of "Stimulated crystals" and rate of nucleation during recrystallisation of aluminium,' 1947 *Nature*, **160,** 398.

Carlisle, S. S. *The Engineer*, Oct. 29, 1948.

Chapman, Prof. S. Cf. 'The supposed fundamental geomagnetic field,' 1948 *Ann. de Géophysique*, **4,** 109; 'Solar magnetism and the supposed magnetisation by rotation,' to appear in *Monthly Notices of R.A.S.*

Gabor, Dr. D. Cf. 'A new microscopic principle,' 1948 *Nature*, **161,** 777.

Hodgkin, Mrs. D. Cf. Chapter XI of *The Chemistry of Penicillin*, Princetown University.

Lonsdale, Dr. Kathleen. Cf. 1942 *Proc. Phys. Soc. Lond.*, **54,** 314; 1943 *Rep. Phys. Soc. Progr. Phys.*, **9,** 256.

Neville, Prof. E. H. Cf. Introductions to *Farey series of order* 1025, and *Cortesian-Polar Conversion Tables*, to be published by the Mathematical Tables Committee of the Royal Society.

Pedoe, Dr. D. *Methods of Algebraic Geometry*, Vol. II, to be published by C.U.P. Cf. 'A new analytical representation of curves in space,' 1947 *Proc. Camb. Phil. Soc.* **43,** Part 4.

Perutz, Dr. M. F. Cf. Boyes-Watson, Davidson and Perutz, 'An X-ray study of horse methaemoglobin I,' 1947 *Proc. Roy. Soc.*, A, **191,** 83.

Runcorn, S. R. Cf. 'The radial variation of the earth's magnetic field,' *Proc. Phys. Soc.*, Oct. 1948.

Shoenberg, Dr. D. Cf. Desirant and Shoenberg, 1948 *Proc. Phys. Soc.*, **60,** 413.

Uttley, Dr. A. M. 1948 *Nature*, **162,** 144.

Williams, Major W. W. Cf. 'The determination of the gradients of enemy-held beaches,' 1946 *Geog. J.*, **109,** 76.

SECTION B

The papers given on 'Building materials' appeared in *The Builder* on Sept. 17, Sept. 24, Oct. 1 and Oct. 15, 1948.

SECTION C

Mott, P. G. *Petroleum*, Sept.–Oct., 1948.

Ongley, P. A. Cf. 1946 *New Zealand Science Review*, **4,** No. 1; *New Zealand J. of Sc. & Technology*, July 1948.

SECTION D

Symposium on 'British marine fisheries,' 1948 *Nature*, **162,** 641.

Discussion on 'Colour and colour vision in animals,' 1948 *Nature*, **162,** 600.

Discussion on 'Scientific aspects of colonial development,' 1948 *Nature*, **162,** 556.

Cannon, Prof. H. G. 1947 *Phil. Trans. Roy. Soc.*, B, **233,** 595.

Carter, Dr. G. S. Cf. 1946 *Science Progress*, **34,** 547.

Holt, S. J. Cf. 1947 *Rapp. et Proc. Verb., Intern. Con. Exp. de la Mer*, **122**; 1947 *Nature*, **159,** 714.

Lowe, Miss R. H. Expected to appear in a series of Colonial Fish Research Reports.

Newell, Dr. G. E. Cf. 'The rôle of the body fluid in relation to movement in soft-bodied invertebrates: I. The burrowing of *Arenicola*,' 1947 *Proc. Roy. Soc.*, B, **134,** 431; 'A contribution to our knowledge of the life history of *Arenicola marina* L. 1948 *J. Mar. Biol. Ass.*, **27,** No. 3.

Rainey, Dr. R. Expected to appear in *Empire Cotton-Growing Review.*

Raymont, Prof. J. E. G. Cf. 'The bottom fauna and the food of flatfishes in a fertilised sea-loch,' *Proc. Roy. Soc. Ed.* B, **63,** Part I (No. 4) ; 'An account of the further changes in the bottom fauna consequent on fertilisation,' *J. Marine Biol. Ass.* (in press).

Smith, J. E. Cf. 1945 *Biol. Rev.*, **20,** 29–43 ; 1946 *Phil. Trans. Roy. Soc.*, B, **232,** 279–310 ; 1947 *Q.J.M.S.*, **88,** 1–14.

Steven, G. A. 1948 *J. Mar. Biol. Ass.*, **27,** 2, 517–539.

SECTION E

Symposium on 'Movements of population in the British Commonwealth,' 1948 *Nature*, **162,** 718.

Gilbert, E. W. Expected to appear in *Geographical Journal.*

Mogey, J. M. Cf. 1947 *Rural life in N. Ireland*, O.U.P. ; 1948 *Man*, **48,** No. 98.

Morgan, F. W. Cf. 'Pre-war hinterlands of the German North Sea ports,' *Trans. Inst. Brit. Geographers*, 1948 ; 'Rotterdam and waterway approaches to the Rhine,' *Economic Geography*, Jan.-March 1948.

Smith, Wilfred. Cf. 1942 *The distribution of population and location of industry on Merseyside.*

Steel, Dr. R. W. 1948 *Nature*, **162,** 556.

Thomas, Prof. Brinley. 1948 *Nature*, **162,** 718. Cf. 'Migration and the British Commonwealth,' *Eugenics Rev.* Oct. 1948.

SECTION F

Bowen, Prof. I. 1948 *Bull. Dept. Economics, U.C. Hull*, **1,** No. 1.

Dennison, S. R. *Lloyds Bank Review*, Dec. 1948.

Paish, F. W. *Westminster Bank Review*, Nov. 1948.

Tress, R. C. *Economica*, Nov. 1948.

SECTION G

A general account of the activities of the Section and of discussions on the various papers appeared in *Engineer* and *Engineering* on Sept. 10, 17, 24, Oct. 1, 8, 15, 1948.

Discussion on 'Applicable Mathematics,' 1948 *Nature*, **162,** 582.

Allen, D. N. de G. *Engineering*, Nov. 5, 1948.

Bickley, Prof. W. G. *Engineering*, Dec. 3, 1948.

Bulleid, O. V. S. *Engineer*, Oct. 1, 1948.

Davies, Prof. S. J. *Engineering*, Sept. 17, Sept. 24, 1948.

Desmond, D. J. *Engineering*, Oct. 22, 1948.

Dudding, Dr. B. P. and Jennett, W. J. *Engineering*, Oct. 22, 29, 1948. Cf. 'Statistical methods and industrial efficiency,' *Proc. 8th International Management Congress*, 1947.

Good, P. *Engineering*, Oct. 1, 1948.

Hartshorn, Dr. L. *Engineering*, Sept. 24, 1948.

Hempson, J. G. G. *Engineering*, Oct. 29, 1948.

Johnson, P. *Engineering*, Oct. 1, 1948.

Rowell, Dr. H. S. *Engineering*, Oct. 8, 1948.

Snow, F. S. *Engineering*, Nov. 19, 1948.

Swan, A. W. *Engineering*, Oct. 15, 1948. Cf. *J. Iron & Steel Inst.*, Sept. 1948.

SECTION H

Discussion on Early Agriculture. *Archaeological News-Letter*, Nov. 1948.

Discussion on 'Primitive techniques and their influence on economic organisation,' 1948 *Nature*, **162,** 602.

Brice, W. C. Expected to appear in *J. Brit. School of Arch. in Iraq.*

Curwen, Dr. E. Cecil. *Archaeological News-Letter*, Nov. 1948. Cf. 1947 *Antiquity*, 155.

MacCulloch, Canon, J. A. To appear in *Folklore.*

Payne, F. G. *Archaeological News-Letter*, Nov. 1948. Cf. *Archaeological J.*, **104,** 82–111.

SECTION I

Discussion on 'The changing aspects of nutrition,' 1948 *Nature*, **162,** 543.

Discussion on 'Colour vision,' 1948 *Nature*, **162,** 639.

Discussion on 'Physiology of lactation,' 1948 *Nature*, **162,** 600.

Discussion on 'Transmission of effects from the endings of nerve fibres,' 1948 *Nature*, **162,** 558.

Fleisch, Prof. A. Cf. *Ernährungsprobleme in Mangelzeiten*, Benno Schwabe, Basle ; 'Nutrition in Switzerland during the war,' 1946 *Scweiz. med. Wochenschrift*, No. 37/38, 889.

Gairns, Dr. F. W. *Trans. Roy. Soc. Ed.*, **61,** Part 3.

Howie, Dr. J. W. Expected to appear in *Brit. J. Nutrition.*

Miller, Prof. F. R. 1948 *Nature*, **162,** 559 ; *Brit. Med. J.* July 17, 1948, p. 160. Cf. 1937 *J. Physiol.*, **91,** 212 ; 1940 *J. Neurophysiol.*, **3,** 131 ; *Proc. Soc. Exp. Biol.*, N.Y., 1943, **54,** 285.

Richardson, Dr. K. C. Cf. 'Some structural features of the mammary tissues,' 1947 *Brit. Med. Bull.*, **5,** 123–129 ; 'Contractile tissues in the mammary gland, with special reference to myoepithelium in the goat,' *Proc. Roy. Soc.*, B (in press).

Warren, Dr. Marjory. Cf. 'Care of the chronic aged sick,' *Lancet*, June 8, 1948.

Wright, Dr. W. D. Cf. 1946 *Researches on normal and defective colour vision*, Henry Kimpton, London.

SECTION J

Discussion on 'The nature of incentives,' 1948 *Nature*, **162,** 557.

Balchin, N. 19*th Century*, Nov. 1948.

Curle, A. To appear in *Human Relations*, Vol. 2, No. 1.

Eysench, Dr. H. J. 19*th Century*, Nov. 1948.

Jaques, Dr. E. Cf. 'Field theory and industrial psychology,' *Occupational Psychology*, July 1948 ; 'Interpretive group discussion as a method of facilitating social change,' 1948 *Human Relations*, **1,** No. 4.

Kesterton, Miss B. To appear in *Educational Review* (J. of Inst. of Educ., Birmingham U.).

Lampard, Miss D. M. To appear in *Educational Review* (J. of Inst. of Educ., Birmingham U.).

Mace, Prof. C. A. 19*th Century*, Dec. 1948 Cf. *Occupational Psychology*, Jan. 1948.

Pear, Prof. T. H. Cf. 'The relations between psychology and sociology,' *Bulletin of the John Rylands Library*, 1948.

Simson, W. A. *Educational Review*, Oct. 1948 and Feb. 1949.

Vernon, Miss M. D. Expected to appear in *Brit. J. Psych.* Cf. 'The relation of cognition and phantasy in children' ; 1940 *Brit. J. Psych.*, **30,** 273–294, 1940 *Ibid.*, **31,** 1–21.

Vernon, Dr. P. E. To appear in *Brit. J. of Educ. Psych.* (1949), No. 19.

SECTION K

Symposium on ' The genetical structure of plant populations,' 1948 *Nature*, **162**, 517.

Bateman, Dr. A. J. Cf. 1946 *Nature*, **157**, 752 ; 1947 *J. Genet.*, **48**, 257 ; 1947 *Heredity*, **1**, 235, 303.

Macdonald, J. A. To appear in *Proc. Roy. Soc. Ed.*, B.

Makins, F. K. Expected to appear in *Q.J. Forestry*.

Rishbeth, J. To appear in *Forestry*, **22**, No. 2.

Valentine, Dr. D. H. Cf. ' Studies in British Primulas,' 1947 *New Phytologist*, **46**, 229 ; 1948 *Ibid.*, **47**, 111.

Walton, Prof. J. To appear in *Trans. Roy. Soc. Ed.*, Vol. 61, part 3.

SECTION L

Discussion on ' Selection at University level.' 1948 *Nature*, **162**, 626.

Discussion on ' The young worker in industry,' 1948 *Nature*, **162**, 667.

Beloe, R. Published as a pamphlet by the National Committee for Visual Aids in Education.

Birley, R. Cf. *The German problem and the responsibility of Britain*, S.C.M. Press.

Clarke, Sir Fred. *Education*, Sept. 24, 1948 ; *Schoolmaster*, Sept. 12, 1948.

Trevelyan, J. *Schoolmaster*, Sept. 16, 1948.

SECTION M

Discussion on ' Control of environment in horticulture,' 1948 *Nature*, **162**, 584.

Discussion on ' Inbreeding and hybrid vigour,' 1948 *Nature*, **162**, 642.

Bewley, Dr. W. F. 1948 *Nature*, **162**, 584.

Donald, Dr. H. P. To appear in *J. Royal Agricultural Soc. of England*.

Fisher, Prof. R. A. Cf. *The theory of inbreeding*, to be published by Oliver and Boyd.

RESEARCH COMMITTEES, 1948–49

Grants of money, if any, from the Association for expenses connected with researches are indicated in heavy type.

SECTION A.—MATHEMATICS AND PHYSICS.

Seismological investigations.—Dr. R. Stoneley, F.R.S. (*Chairman*), Lt.-Col. E. Tillotson (*Secretary*), Mr. E. F. Baxter, Miss E. F. Bellamy, Prof. P. G. H. Boswell, O.B.E., F.R.S., Mr. B. C. Browne, Dr. G. E. R. Deacon, F.R.S., Dr. A. T. J. Dollar, Dr. A. E. M. Geddes, O.B.E., Prof. G. R. Goldsbrough, F.R.S., Dr. Wilfred Hall, Mr. M. N. Hill, Dr. O. J. R. Howarth, O.B.E., Mr. J. S. Hughes, Prof. H. Jeffreys, F.R.S., Mr. Cosmo Johns, Mr. E. N. Lawrence, Dr. A. W. Lee, Prof. J. Proudman, F.R.S., Dr. A. O. Rankine, O.B.E., F.R.S., Rev. C. Rey, S.J., Dr. G. D. Robinson, Rev. J. P. Rowland, S.J., Dr. F. J. Scrase, Dr. H. Shaw, Mr. H. V. Shaw, Sir Frank Smith, G.C.B., G.B.E., F.R.S., Dr. J. M. Stagg, Mr. P. L. Willmore.

SECTION C.—GEOLOGY.

To excavate critical geological sections in Great Britain.—Prof. W. T. Gordon (*Chairman*), Prof. W. G. Fearnsides, F.R.S. (*Secretary*), Sir Edward Bailey, M.C., F.R.S., Mr. J. L. Begg, Mr. W. S. Bisat, F.R.S., Prof. P. G. H. Boswell, O.B.E., F.R.S., Prof. A. H. Cox, Mr. E. E. L. Dixon, Dr. Gertrude Elles, M.B.E., Prof. H. L. Hawkins, F.R.S., Prof. G. Hickling, F.R.S., Dr. R. G. S. Hudson, Prof. V. C. Illing, F.R.S., Prof. O. T. Jones, F.R.S., Dr. Murray Macgregor, Dr. L. R. Moore, Dr. F. J. North, Dr. W. E. Swinton, Dr. Mabel E. Tomlinson, Dr. F. S. Wallis, Prof. D. M. S. Watson, F.R.S., Dr. T. S. Westoll, Mr. T. H. Whitehead, Prof. W. F. Whittard, Prof. S. W. Wooldridge. **£20.**

To consider and report on questions affecting the teaching of geology in schools.—Dr. A. E. Trueman, F.R.S. (*Chairman*), Dr. Mabel E. Tomlinson (*Secretary*), Prof. A. H. Cox, Mr. J. Davies, Miss Gaynor Evans, Prof. W. G. Fearnsides, F.R.S., Prof. T. N. George, Prof. G. Hickling, F.R.S., Prof. D. E. Innes, Prof. W. J. Pugh, Dr. A. K. Wells, Miss M. A. Arber, Dr. L. R. Moore, Prof. A. Wood.

The collection, preservation, and systematic registration of photographs of geological interest.—Prof. H. L. Hawkins, F.R.S. (*Chairman*), Mr. G. S. Sweeting (*Secretary*), Mr. H. Ashley, Dr. A. J. Bull, Mr. G. Macdonald Davies, Dr. A. G. MacGregor, Dr. F. J. North, Dr. A. Raistrick, Mr. J. Ranson, Prof. S. H. Reynolds.

SECTION D.—ZOOLOGY.

To nominate competent naturalists to perform definite pieces of work at the Marine Laboratory, Plymouth.—Prof. H. G. Jackson (*Chairman*), Prof. J. E. Harris (*Secretary*), Prof. H. Munro Fox, F.R.S., Dr. C. F. A. Pantin, F.R.S., Mr. F. S. Russell, F.R.S., Prof. C. M. Yonge, F.R.S. **£50.**

To co-operate with other sections interested, and with the Zoological Society for the purpose of obtaining support for the Zoological Record.—Mr. M. A. C. Hinton, F.R.S. (*Chairman*), Dr. J. P. Harding (*Secretary*), Dr. I. Gordon, Mr. N. B. Kinnear, Dr. O. W. Richards. **£50.**

SECTIONS D, K.—ZOOLOGY, BOTANY

To consider the position of biology in the school curriculum and matters relating thereto.—(*Chairman and Secretary to be appointed*), Mr. H. J. Bonham, Prof. H. G. Cannon, F.R.S., Prof. R. J. D. Graham, Prof. T. M. Harris, F.R.S., Mr. W. J. Heasman, Dr. L. M. J. Kramer, Prof. Lily Newton, Prof. C. H. O'Donoghue, Dr. H. Hamshaw Thomas, M.B.E., F.R.S., Prof. J. Walton, Mr. A. J. A. Woodcock. **£5.**

To aid competent investigators selected by the committee to carry out definite pieces of work at the Freshwater Biological Station, Wray Castle, Windermere.—Prof. F. E. Fritsch, F.R.S. (*Chairman*), Mr. H. C. Gilson (*Secretary*), Prof. P. A. Buxton, F.R.S., Dr. G. S. Carter, Miss P. M. Jenkin, Prof. W. H. Pearsall, F.R.S. **£50.**

To aid competent investigators selected by the committee to carry on definite pieces of work at the Zoological Station at Naples.—Dr. C. F. A. Pantin, F.R.S. (*Chairman & Secretary*), Prof. H. Munro Fox, F.R.S., Prof. F. E. Fritsch, F.R.S., Prof. A. C. Hardy, F.R.S., Dr. Margery Knight, Prof. Lily Newton, Prof. J. Z. Young, F.R.S. **£50.**

Co-ordinating committee for Cytology and Genetics.—Prof. R. A. Fisher, F.R.S. (*Chairman*), Mr. J. L. Crosby (*Secretary*), Dr. D. G. Catcheside, Prof. F. A. E. Crew, F.R.S., Dr. C. D. Darlington, F.R.S., Dr. E. B. Ford, F.R.S., Dr. J. Hammond, F.R.S., Prof. T. J. Jenkin, Dr. P. C. Koller, Prof. I. Manton, Prof. K. Mather, Prof. L. S. Penrose, Dr. G. Pontecorvo, Dr. R. R. Race, Dr. P. T. Thomas, Dr. W. B. Turrill, Prof. C. H. Waddington, F.R.S. **£5.**

SECTION E.—GEOGRAPHY.

To consider and report upon ambiguities and innovations in geographical terminology.—Prof. E. G. R. Taylor (*Chairman*), Mr. A. E. Smailes (*Secretary*), Prof. E. G. Bowen, Prof. W. G. East, Mr. T. W. Freeman, Mr. H. King, Prof. R. H. Kinvig, Prof. D. L. Linton, Dr. A. E. Moodie, Dr. C. P. Snodgrass, Mr. A. Stevens, Prof. S. W. Wooldridge. **£5.**

To collect records of the revival of Geography in the British Isles dating from the later years of the nineteenth century.—Mr. J. N. L. Baker (*Chairman*), Mr. T. W. Freeman (*Secretary*), Prof. H. C. Darby, Prof. W. G. East, Dr. A. Geddes, Dr. O. J. R. Howarth, O.B.E., Prof. D. L. Linton. **£5.**

To promote and co-ordinate studies in the British Isles of Urban geography.—Prof. C. B. Fawcett (*Chairman*), Mr. A. E. Smailes (*Secretary*), Mr. M. R. G. Conzen, Dr. A. Geddes, Mr. E. W. Gilbert, Dr. E. C. Willatts. **£5.**

SECTIONS E, H.—GEOGRAPHY, ANTHROPOLOGY.

To collect and record information on demography and seasonal activities in relation to environment in Inter-Tropical Africa.—Prof. C. Daryll Forde (*Chairman and Secretary*), Prof. F. Debenham, O.B.E., Dr. M. Fortes, Dr. M. Gluckman, Prof. A. G. Ogilvie, O.B.E., Dr. Audrey Richards, Mr. R. W. Steel. **£5.**

SECTION H.—ANTHROPOLOGY.

To co-operate with the Torquay Natural History Society in investigating Kents Cavern.—Mr. M. C. Burkitt (*Chairman*), Prof. V. G. Childe (*Secretary*), Mr. A. L. Armstrong, Prof. D. A. E. Garrod, Mr. A. G. Madan, Dr. K. P. Oakley, Prof. F. E. Zeuner. **£10.**

To co-operate with a committee of the Royal Anthropological Institute in the exploration of caves in the Derbyshire district.—Mr. M. C. Burkitt (*Chairman*), Mr. A. Leslie Armstrong (*Secretary*), Dr. Arthur Court, Prof. H. J. Fleure, F.R.S., Prof. D. A. E. Garrod, Dr. J. Wilfred Jackson, Prof. L. S. Palmer. **£25.**

To report on the composition of ancient metal objects.—Prof. V. Gordon Childe (*Chairman*), Dr. C. H. Desch, F.R.S. (*Secretary*), Dr. W. G. Broomhead, Mr. H. H. Coghlan, Prof. H. J. Fleure, F.R.S., Prof. C. F. C. Hawkes, Mr. M. E. L. Mallowan, Mr. H. Maryon.

To carry out research among the Ainu of Japan.—Mrs. C. G. Seligman (*Chairman and Secretary*), Rt. Hon. Lord Raglan, Mr. Arthur Waley. **£25.**

To report to the Sectional Committee on the question of re-editing 'Notes and Queries on Anthropology.'—Prof. H. J. Fleure, F.R.S. (*Chairman*), Mrs. C. G. Seligman (*Secretary*), Prof. W. E. le Gros Clark, F.R.S., Mr. A. Digby, Prof. E. E. Evans-Pritchard, Prof. C. Daryll Forde, Prof. J. H. Hutton, C.I.E. **£25.**

SECTION H.—ANTHROPOLOGY

EXPLORATION OF CAVES IN THE DERBYSHIRE DISTRICT

INTERIM REPORT of COMMITTEE appointed to co-operate with a Committee of the Royal Anthropological Institute in the exploration of caves in the Derbyshire district. Mr. M. C. Burkitt, *Chairman*; Mr. A. Leslie Armstrong, *Secretary*; Dr. Arthur Court, Prof. H. J. Fleure, F.R.S., Prof. D. A. E. Garrod, Dr. J. Wilfred Jackson, and Prof. L. S. Palmer.

No new sites have been excavated by the Committee during the past year, but the excavation of Whaley Rock Shelter, No. 2, by Mr. Leslie Armstrong, Dr. Arthur Court, and Mr. W. H. Hanbury, has proceeded steadily and is now nearing completion. Facilities have been given there for students of archæology to obtain practical experience in the technique of cave excavation and general oversight and advice has been given, by request, respecting work carried out independently in other parts of Derbyshire and S. Yorkshire.

Mr. Leslie Armstrong reports in regard to *Whaley Rock Shelter, No. 2*, that progress has been considerably slower than was anticipated, owing in part to transport difficulties, but mainly to the excessive number of large slabs of rock encountered and the restricted space in which they had to be dealt with. Section 'B' has been completed and it is expected that Section 'C,' in which the skull of a woman was found in July 1947, will be finished before the end of the present season. This work has provided valuable new evidence and strengthened that previously obtained. The principal results are briefly as follows :—

Section 'B.'—The total depth of this Section below the edge of the cliff was 15 ft. 4 in.; the depth below the datum line was 12 ft.; of which 11 ft. was composed of Pleistocene cave earth in two zones, the upper, red, earth 8 ft. in thickness and the lower, yellow, earth 2 ft. 6 in. in thickness, which enclosed the Mousterian levels.

The two horizons of Mousterian culture observed in Section 'A' were confirmed and yielded artifacts of quartzite, chert, and limestone, similar to those found in the Mousterian levels of the Pin Hole Cave, Creswell. They are few in number, denoting that the occupations were casual and never long protracted in any period. The yellow cave earth in which the living levels occur, is hard and compact, very calcareous and shows evidence of lamination and waterlogging. In the area examined the last twelve inches was entirely sterile and rested upon a base consisting of extremely fine sand, apparently wind borne, which resembles loess

and was probably derived from neighbouring Triassic formations. This sand was completely sterile, entirely free from stones and bright yellow in colour, but contained local streaks and pockets of a somewhat coarser sand, ferruginous red in colour. The total depth of this deposit was not ascertained, but it was proved to a depth of 1 ft. 6 in. and probed to a further 2 ft.

Section ' C.'—At the date of writing this report the excavation has reached a depth of 8ft. below datum. The skull horizon, proto-Solutrean in culture, has yielded a human patella ; several phalanges ; three vertebræ ; and three molar teeth. From their robust character, however, it seems unlikely that any of these are parts of the individual represented by the skull found in 1947. The most notable artifacts recovered include blades and points of Lower Creswellian type and a double-edged knife, exhibiting a slight notch at one side of the base and proto-Solutrean technique. The bone tools include an awl and several marrow scoops.

In the Lower Creswellian (Aurignacian) horizon the living levels were well marked by conspicuous ' black bands ' and scattered charcoal and a definite hearth, edged by stones, occurred at 6 ft. below datum close to the wall of the cliff. Throughout the zone scattered human remains have been found, consisting of vertebræ and phalanges ; occurrences which have been noted throughout these excavations. Artifacts of flint have been scarce, other than flakes, but numerous artifacts of stone have been recovered, indicative of the scarcity of flint as a raw material. Further specimens of the interesting flint microliths recorded last year as occurring in Section ' B ' have been found on the same horizons, but, on the whole, they are inferior in workmanship to the previous examples. The tips of two more bone spears, or harpoons, have also been recovered, supplementing the specimens found at the same level in Section ' B,' but of different type ; also marrow scoops and utilised split bones. Animal remains have duplicated previous records, the most important being part of the jaw of a young Rhinoceros and a tooth of a Hyæna.

It is now clear that Sections ' B ' and ' C ' originally formed a cave and that the collapse of the roof over the ' B ' portion was a gradual procedure from Mousterian times to about the middle of the Cresswellian occupation, by which time a strip less than 9 in. wide and extending the full length of the section became exposed to the open air ; the ' C ' portion remaining a cave. The downfall of the roof over Section ' C ' was also gradual, but appears to have terminated in a sudden and complete collapse at a time subsequent to the burial of the skull of ' Mrs. Whaley.' The proto-Solutrean occupation continued on top of the fallen slabs.

The Skull.—The skull found in 1947 has been carefully and successfully restored by Leslie Armstrong and proves to be more complete than was anticipated. Though cracked into 68 fragments by the pressure of several tons of rock which covered it, there is no distortion. The maxillæ and base of the skull have apparently been deliberately removed, presumably for access to the brain, and it is significant that a reindeer antler tool of the marrow scoop type was extracted from the interior of the cranium by Sir Arthur Keith when he removed the skull from the enclosing matrix of cave earth. The restoration has revealed unsuspected evidence of death by violence, which is provided by five square holes in the occipital and parietal bones which are believed to mark the points of penetration by spears of wood, or bone. From the position in which the skull rested when found, it would appear that it had received ceremonial burial. Sir Arthur Keith, F.R.S., has kindly undertaken to describe this important skull.

Supervision and advice has been given by the Secretary in regard to the following work which is being carried out independently :—

Demon's Dale.—A rock shelter in the narrow ravine known as Demon's Dale, near Ashford, is in course of excavation by Major T. Harris. The shelter reveals evidence of occupation extending from Neolithic to Roman times, but casual and not extensive at any time. It has yielded a series of typical implements in the Neolithic and Bronze Age horizons, of which a high proportion are fabricated in the best Derbyshire black chert, of local origin. The lowest level of the excavation is suspected to be Mesolithic in age, but this has not yet been definitely established. No Pleistocene deposit has yet been encountered ; but the base has not been reached.

Elderbush Cave, Manifold Valley.—This cave was partially excavated by the Rev. J. Wilson prior to the late War. Work has been recommenced by Mr. D. Bramwell, of Bakewell, who, assisted by members of the Peakland Archæological Society, has excavated the platform in front of the cave. Previous records have been confirmed indicative of casual occupations ranging in time from Neolithic to Roman, which is so typical of the caves in central Derbyshire. The lower levels of the cave are rich in the remains of Pleistocene animals, but no precise evidence has been obtained of human occupation in that period, though two ' long ' flakes found on the top of this deposit might be assigned to the final Palæolithic ; or to the early Mesolithic, with equal probability.

The Committee desires to be reappointed and makes request for a grant to assist in the initiation of excavations in a cave at Whitwell, in the Creswell area.

REPORT OF THE COUNCIL TO THE GENERAL COMMITTEE, 1947–48

Obituary

1. The Council have to deplore the loss by death during the last year of three past Presidents of the Association, namely Professor F. O. Bower, F.R.S. (1930), Professor W. W. Watts, F.R.S. (1935) and the Rt. Hon. Lord Rayleigh, F.R.S. (1938).

The Association was represented at the funeral of Lord Rayleigh by Sir Henry Dale, O.M., G.B.E., F.R.S. (then President), and at a memorial service for Professor Watts by Professor F. T. Brooks, C.B.E., F.R.S., and Professor F. J. M. Stratton, O.B.E., F.R.S., who were General Secretaries during his presidential year.

The Association has also suffered the loss of the following office bearers and supporters :—

Prof. E. C. C. Baly, C.B.E., F.R.S.
Viscount Bennett, P.C.
Dr. Vaughan Cornish
Dr. A. L. Du Toit, F.R.S.
Mr. E. H. Fryer
Sir Robert Greig
Prof. J. M. Gulland, F.R.S.
Sir Albert Howard, C.I.E.
Dr. C. W. Kimmins
Mr. J. J. Shaw, C.B.E.
Sir D'Arcy Thompson, C.B., F.R.S.
Dr. T. W. Woodhead

Relations with other Institutions

2. Representatives of the Association were appointed by the Council as follows :—

First Annual Conference of the National Foundation for Adult Education. Mr. W. O. Lester Smith, C.B.E.

Joint Committee for Anthropological Research and Teaching. Dr. H. S. Harrison to serve for a further term of five years.

Committee of the Royal Society to consider the accommodation of Scientific Societies. Sir Henry Dale, O.M., G.B.E., F.R.S.

Ceremonies arranged by the Royal Society of Edinburgh in commemoration of James Hutton. Dr. M. Macgregor.

Installation of the Chancellor of Toronto University. Prof. Griffith Taylor and Prof. H. Wasteneys.

Annual Meeting of the Indian Science Congress Association at Patna, 1948. Prof. Alexander Findlay.

International Geological Congress, London, 1948. Prof. H. H. Read, F.R.S., and Dr. A. E. Trueman, F.R.S.

Annual Meeting of the French-Canadian Association for the Advancement of Science, 1947. Sir Henry Dale, O.M., G.B.E., F.R.S.

Annual Meeting of the French Association for the Advancement of Science, 1948. Sir Richard Gregory, Bt., F.R.S., and Lady Gregory.

Installation of the Chancellor of Sheffield University. The President (Sir Henry Tizard, K.C.B., F.R.S.).

Congress of Universities of the Commonwealth and Empire (Oxford). The President (*ex-officio* a vice-president of the Congress).

International Congress of Anthropology and Ethnology at Brussels. Prof. H. J. Fleure, F.R.S.

Jubilee Celebrations of the Polish Academy of Sciences and Letters in late September. Sir John Russell, F.R.S., and Sir Harold Spencer Jones, F.R.S.

3. Through their Officers and Members the Council have maintained contact with scientific and cultural organisations at home and abroad.

Dr. Kirtley F. Mather, a General Secretary of the American Association for the Advancement of Science was present at the Meeting in Dundee and delivered the British-American Association Lecture on Petroleum Today and Tomorrow. He was empowered by his Association to discuss with Officers of the British Association the possibility of a joint meeting in Canada. Subsequently Officers of the two Associations discussed the matter by correspondence and the Council considered a proposal that it might be possible to arrange a meeting of the two Associations together with Canadian Associations in 1951. As it is not possible at this stage to assume that the dollar stringency will have eased by 1951 and as that year would in any case be one in which a special effort would be required at home in connection with the centenary of the 1851 Exhibition, the Council have decided that it is not practicable to plan a joint meeting in North America in that year and have made other proposals for co-operation in the near future.

The American Association celebrates its Centenary in September and the Council have despatched a message of congratulation.

4. The Council were pleased to be represented at the First Annual Meeting of the Indian Science Congress Association since partition of India and to learn from Professor Alexander Findlay of the cordial reception he received at Patna. It is understood that the establishment of a new Association in Pakistan is contemplated.

5. Through the British Council the Officers have been put in touch with men of science in Brazil who wish to found an Association on our model. The Council record their thanks to the British Council for this and other work of liaison with organisations and individuals in other countries, and for grants of money to assist with the entertainment of overseas visitors to the Annual Meetings at Dundee and Brighton.

6. Five members of Council are associated with the work of UNESCO as members of Co-operating Bodies in Britain, and the Director-General has accepted the invitation of Council to arrange a session at Brighton on the work of UNESCO.

7. Jubilee celebrations in Rhodesia, planned for 1940 and delayed owing to the war, will take place in 1950. In this connection the Council have had notice that the Association may receive an invitation to appoint a delegation to take part, with a similar delegation from the South African Association, in a scientific meeting in Salisbury in the summer of that year.

Finance

8. The General Treasurer's Statement and Account for the financial year ending March 31, 1948, will be submitted to the General Committee.

9. The sums so far received in response to the appeal for a Development Fund amount to £5,750. This sum includes an unconditional gift of £5,000 from the Pilgrim Trust and a number of smaller donations, all of which have been gratefully acknowledged. It also includes a donation of £100 made by the Dundee Local General Committee from the unexpended balance of the Local Fund (see also paragraph 27).

Officers and Council

10. *President*, 1949.—The Council's nomination to the office of President of the Association for the year 1949 (Newcastle Meeting) will be submitted at Brighton.

11. *Chairman of Council.*—Under Regulation 3 the Council appointed Dr. C. Tierney to this office in 1946.

12. *General Officers*, 1948–49.—The Council nominate the following :—

General Treasurer : Mr. M. G. Bennett.

General Secretaries : Dr. Edward Hindle, F.R.S., and Sir Richard Southwell, F.R.S.

13. *Other Members of Council.*—The Council has lost from its membership Mr. R. F. Harrod by retirement and has co-opted Professor P. Sargant Florence in his stead.

The members retiring under Statute III, 3, are : Sir Frederick Bartlett, C.B.E., F.R.S., Sir Arthur Fleming, C.B.E., Prof. H. J. Fleure, F.R.S., Sir John Graham Kerr, F.R.S., M.P., and Prof. J. W. Munro.

The Council nominate as new members Prof. F. Balfour-Browne, Lord Rennell of Rodd, K.B.E., C.B., and Mr. H. E. Wimperis, C.B.E. ; leaving two vacancies in the Ordinary Membership to be filled by the General Committee without nomination by the Council. If the Council's nominations are approved, the two remaining places should be filled by representatives of Sections J (Psychology) and L (Education).

The full list of nominations of Ordinary Members is as follows :—

Sir Edward Appleton, G.B.E., K.C.B., F.R.S.
Prof. F. Balfour-Browne
Prof. J. D. Bernal, F.R.S.
Prof. D. Burns
Ritchie Calder, C.B.E.
Wing-Comm. T. R. Cave-Browne-Cave, C.B.E.
Prof. W. E. Le Gros Clark, F.R.S.
Prof. Winifred Cullis, C.B.E.
Dr. C. D. Darlington, F.R.S.
Sir Charles Darwin, K.B.E., F.R.S.
Dr. H. J. T. Ellingham
Prof. C. B. Fawcett
Dr. K. G. Fenelon
Prof. P. Sargant Florence
Dr. J. C. Maxwell Garnett, C.B.E.
James Hornell
Dr. O. J. R. Howarth, O.B.E.
Prof. E. H. Neville
Dr. W. G. Ogg
Prof. H. H. Read, F.R.S.
Lord Rennell of Rodd, K.B.E., C.B.
Dr. J. L. Simonsen, F.R.S.
Dr. C. J. Stubblefield, F.R.S.
Dr. H. Hamshaw Thomas, M.B.E., F.R.S.
Prof. R. G. White
H. E. Wimperis, C.B.E.
Prof. A. W. Wolters

14. *Honorary Auditors*, 1948–49. — The Council nominate : Dr. Ezer Griffiths, F.R.S., and Mr. R. S. Whipple.

General Committee

15. The following have been admitted as members of the General Committee on the nomination of Sectional Committees :—

Section A : Mr. E. S. Shire, Prof. R. W. Ditchburn.
Section B : Dr. L. A. Jordan.
Section C : Prof. T. N. George.

Section E : Prof. G. H. J. Daysh, Dr. H. C. K. Henderson.
Section F : Prof. G. Walker.
Section G : Dr. A. P. Hall.
Section J : Dr. R. W. Pickford.

Lectures and Conferences

16. Two of the three memorial lectures maintained by the Association fall due to be delivered in 1948. The Council has appointed Professor P. M. S. Blackett, F.R.S., to give the Norman Lockyer Lecture in Newcastle-upon-Tyne on 'Why the Earth is a Magnet,' and Professor F. T. Brooks, C.B.E., F.R.S., to give the Alexander Pedler Lecture in Dundee on 'Fungi and their Economic Importance.'

17. The British-American Association Lecture, which would normally have been delivered by a British scientist in America in 1948, has been deferred till 1949 at the request of the American Association.

18. The Division for Social and International Relations of Science held a Conference at Leamington Spa on May 8, 1948, on the subject Human Factors in Industry. The Conference was held in two sessions, on working conditions and on human relations, at which the President and Sir George Schuster presided. A report of the Conference has been published in the July number of *The Advancement of Science.*

Research

19. Following the Dundee Meeting the Council, on the recommendation of six Sections, appointed 22 research committees with a total membership of 243.

The Council have made the following grants to sixteen committees from the funds under their control :—

Committee.	*Grant.* £	*Fund.*
Mathematical Tables . .	150	Cunningham and Caird
Critical Geological Sections .	20	Hobson
Marine Laboratory, Plymouth	50	Caird
'Zoological Record' . .	50	,,
Biology in Schools . .	5	,,
Biological Station, Wray Castle	50	Musgrave
Zoological Station, Naples .	50	Caird
Cytology and Genetics .	5	Haydock
National Atlas . . .	10	Caird
Geographical Terminology	5	,,
Urban Geography . .	5	,,
Revival of Geography in the British Isles in the Nineteenth Century . .	5	,,
Demography and Environment in Africa . .	5	,,
Kent's Cavern . . .	5	,,
Derbyshire Caves . .	37 10	,,
Notes and Queries in Anthropology	25	,,

Mathematical Tables Committee

20. The Council report that they have completed discussions as a result of which the Royal Society have accepted the responsibility for future developments in the work undertaken by the Mathematical Tables Committee.

The Association has had an interest in Mathematical Tables since 1871, when its first Committee was formed. Of the work of this and subsequent Committees in the collection, computation and publication of Mathematical Tables, the Association has every reason to be proud. The period of major activity dates from 1929 in which year the Cunningham Bequest became available for new tables in the theory of numbers. The volumes which have been published since that date have set standards of accuracy and appearance which have not been excelled, and from them the Association has acquired no little prestige.

The Committee's work developed to such an extent as to require financial support in excess of the annual grants which it is possible for the Association to make from the funds available for research. In the expectation that the work may thereby be supported on an adequate scale, the Association's functions have been transferred to the Royal Society. A new Committee has been appointed by the Royal Society to advise (*a*) on the priorities under which mathematical tabulation should be carried out, (*b*) on the preparation and publication of the tables, and (*c*) on matters generally related to mathematical tables. It is fitting that all the senior and active members of the Association's Committee have been appointed members of the Royal Society's Committee, on which they will have an opportunity of maintaining the traditional objects of the Association in this field.

The Royal Society have accepted all the Association's assets and liabilities on the basis of an agreed assessment and the transfer of responsibility took effect on July 1, 1948.

Publications

21. For the first time since *The Advancement of Science* took the place of the Annual Report in 1939 it has been possible, during the period under review, to publish the journal at quarterly intervals. Printing difficulties have prevented publication on the due dates, but it is hoped that the position will improve.

In Appendix II of the previous Annual Report, which was approved by the General Committee, proposals for modification of publication policy were listed. The Council have put into effect all the proposals which

were found to be practicable. One suggestion which has received attention by the Council, but has not yet matured, was that the Association should publish a Year Book of Science for the Empire. The Council appointed editors and progress was made with a plan of the contents. Protracted discussion with a likely publisher has not, however, led to a satisfactory result, and informal discussion with another publisher has confirmed the view of the first that the production of such a Year Book may not be practicable without endowment. The Officers have been authorised to keep this matter under consideration.

Bureau of Scientific Information

22. In their last report the Council stated that they accepted the responsibility for providing any additional services which might be necessary to co-ordinate existing services for disseminating scientific information to the public. Proposals for a Bureau of Scientific Information have continued to receive attention. Adequate financial support is a prerequisite for an information service and in this connection progress was made to the extent that the Natural Science Committee of UNESCO supported recommendations that the British Association should sponsor any development of this kind and proposed that an appeal should be made to the Government for financial support. It was subsequently judged inadvisable to approach the Government at the present time, and the proposal will be kept under review. In the meantime, anything which can be done, within the limitations of the Association's budget, will be done as opportunity offers or can be made.

Resolutions and Recommendations

23. The Council received three resolutions arising from the Annual Meeting at Dundee and decided as follows :

(*a*) That a resolution from Section C calling for action to accelerate production of the 10 mile to the inch geological map of Great Britain, required no further action as it was ascertained, on enquiry, that the Geological Survey were taking all possible action to complete the map in time for the International Geological Congress.

(*b*) That the following resolution be transmitted to Whitehall :—

> Sections E and H request the Council of the Association to urge the Colonial Office—
>
> (i) to lend financial and other aid to the projected West African Atlas, the preparation of which on an international basis has been begun by the Institut Français d'Afrique Noir with the support of the French Government and the International West African Conference, and
>
> (ii) to encourage the Colonial governments in Africa to prepare and publish maps of the distribution of population showing densities and ethnic composition on scales no smaller than 1/2,000;

(*c*) That the following resolution from the Conference of Delegates of Corresponding Societies be referred to the Publications Advisory Committee for consideration in connection with the Year Book of Science (see para. 21 above).

> 'That the British Association be requested to renew the annual publication of the list of papers published during the year in the Journals of the affiliated Societies.'

24. *National Atlas.*—In the recommendation of Section E (Geography) the Council appointed a Committee to prepare a scheme for a National Atlas. The Committee rapidly completed the drafting work which had been begun before the outbreak of war and, with the support of eight Sections, recommended that urgent steps be taken to secure the interest and support of the Government in organising the production of such an Atlas. The Council have agreed that the Royal Society, on behalf of all interested parties, including the Association and the Royal Geographical Society, should make representations to the Government.

25. *Freedom in Science.*—It was noted in the last report that the Council had sent to all universities in the British Commonwealth a resolution urging that no research contract should normally be accepted by the scientific departments of those universities, if its terms include any restriction on freedom of publication. Copies of the resolution were sent to 85 institutions and the majority of the comments received expressed agreement with the principle involved.

Science in the Economic Crisis

26. At the Dundee Meeting the Council appointed a Committee to advise on any action which might be taken by the British Association to assist the country in its present economic crisis. As at present constituted the Committee consists of Sir Henry Tizard (Chairman), the General Officers (*ex-officio*), Prof. J. D. Bernal, Prof. P. M. S. Blackett, Prof. Winifred Cullis, Dr. C. H. Desch, Dr. H. J. T. Ellingham, Sir Arthur Fleming, Prof. P. Ford, Mr. G. V. Jacks, Sir John Lennard-Jones and Prof. S. Zuckerman. The Committee began by examining a long list of topics suggested for consideration and

has taken evidence from a number of experts. The action so far taken has consisted chiefly in advising the Chairman on matters which he was in a position to follow up in his official capacity and in preparing recommendations for consideration by Sectional Committees when drafting their programmes of items for public discussion at the Brighton Meeting.

British Association (Dundee) Trust

27. In November 1947, the General Committee in charge of the local arrangements for the Dundee Meeting decided to administer £650 of an unexpended balance of the Local Fund for the encouragement of local scientific societies in sympathy with the aims of the British Association. This decision has been made effective by the establishment of the British Association (Dundee) Trust, which will administer the fund of £650 together with any additional subscriptions, donations, legacies or other funds, by making grants (*a*) to assist the work of local scientific societies (*b*) to assist in meeting the expenses of local public lectures in science (*c*) to support research in Dundee and district.

Office and Staff

28. The Association is represented on a Committee appointed by the Royal Society to consider the accommodation of scientific societies in general and, pending any developments in this connection, it appears likely that the administrative affairs of the Association will continue, for the time being, to be conducted from the cramped quarters in Burlington House. The Council gratefully acknowledge the hospitality of the Royal Society and other Societies in Burlington House who provide rooms for meetings of Council and Committees.

29. The Council have reviewed the salaries of permanent staff and have adopted increased scales of payment subject to review in two years. They have also reviewed the Association's pension arrangements and have adopted a more generous basis, on the lines of F.S.S.U.

Down House

30. The number of visitors to Down House in 1947 was 3,497 compared with 3,448 in 1946 and an annual average of 7,000 before the war, when travel was easier and free publicity more generous. An encouraging feature of the present trend is that there is an increase in the number of organised parties from societies and schools.

Precipitation as measured by the standard rain-gauge in 1947 was 27·14 ins. against an average of 32·35 ins. in the preceding 10 years. Information on snowfall has been given, as in 1946–7, to the Society of Glaciology for its snow survey and some of the results have been mentioned in the Report on the Snow Survey of Great Britain for the season 1946–7 by E. L. Hawkes and D. L. Champion in the *Journal of Glaciology*, Vol. I, No. 3, 1948, pp. 124–133.

As noted in previous reports, the experimental plantation of *Lythrum salicaria* (purple loosestrife) has been maintained.

The Milne-Shaw seismographs, which were moved to Down House from Oxford in 1947, have been running regularly since November. A report will be submitted to the Association's Seismology Committee.

During the period under review the Officers of the Association and others interested, have considered further proposals for increasing the scientific use to which the property is put and for reducing the net cost of maintaining the House. No solution of those problems has so far been found, but the possibilities have not yet been exhausted, and one promising proposal is being actively considered.

Regulations

31. The Council have reviewed the Regulations and recommend to the General Committee, for approval, the amendments set out in the Appendix (opposite).

Newcastle Meeting

32. The Council submit with endorsement a recommendation by the Local Executive Committee that the Meeting in Newcastle-upon-Tyne be held during the period August 31-September 7, 1949.

Regulation 3 (Chairman of Council). 'It shall be competent for the Council to appoint a Chairman thereof to serve for a term not exceeding five years.'	*Amendment.* Add an additional sentence 'The Chairman of Council shall not rank among Ordinary Members in respect of retirement according to length of service as an Ordinary Member.'
Regulation 13 (Research Committees). *Paragraph* 3. 'All instruments, drawings, papers, and other property of the Association when not in actual use by a Committee, shall be deposited at the office of the Association.'	*Amendment.* After 'Association' *add* 'or as the Council may otherwise direct.'
Regulation 14 (Corresponding Societies). 'Application made by any Society to be placed on the list of Corresponding Societies may be entertained, provided such application is addressed to the Secretary of the Association on or before June 1 preceding the Annual Meeting at which it is intended that it should be effective.'	*Amendment.* 'Application by any Society to be placed on the list of Corresponding Societies must reach the Secretary of the Association on or before June 1 preceding the Annual Meeting at which it is desired that it should be effective.'
Regulation 19 (Travelling Expenses, etc.). 'The General Treasurer shall be authorised to defray travelling and other expenses as follows:— (i) Fares, postages and other necessary expenses incurred by the President, General Officers and Chairman of Council in connection with the Annual Meeting, the meetings of the Council, and other meetings involved by the discharge of their official duties. (ii) Fares incurred by Members of the Council in attending meetings thereof. (iii) Fares and subsistence expenses incurred by members of the Staff in the discharge of their duties. (iv) Fares incurred by Recorders and Secretaries of Sections in connection with attendance at the Annual Meetings and meetings of the Sectional Committees. (v) Postages and essential clerical expenses incurred by the Recorders (or their Sectional Secretaries on their behalf) in the discharge of their duties, provided that no claim exceeding £10 under this heading by any Recorder in any one year shall be allowed without the express sanction of the Council. (vi) Travelling expenses of Members appointed by the Council to represent the Association at meetings of other bodies, for which formal invitation has been received.'	*Amendments.* *After* 'authorised' *insert* 'within limits determined by the Council from time to time.' *Add:* '(vii) Travelling expenses of such other Members as the Council may from time to time determine.'
Regulation 21. (Offprints). *First sentence.* 'Presidents shall be entitled to receive one hundred copies of their addresses without charge and additional copies at the cost of reproduction.'	*Amendment.* *For* 'one hundred' *substitute* 'fifty.'

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

GENERAL TREASURER'S STATEMENT AND ACCOUNT, 1947–48

THE following accounts for the year ending March 31, 1948, are of special interest as the year includes the period of the Dundee Meeting in 1947, the Association's first Annual Meeting on a full scale since the war. The meeting was attended by over 3,000 people and subscriptions for the year, including life subscriptions brought into income, exceeded £4,000. A high standard has thus been set by which financial results during the next few years may be judged.

As a result of the fuller scale of activity most of the figures of expenditure in the General Income and Expenditure Account are considerably larger than in 1946–47. Nevertheless, the Account shows an excess of £614 Income over Expenditure. In the previous year, when income included £500 from the Government Grant for scientific publications and a final contribution of £911 from the Yarrow Fund, there was an adverse balance of £320. The financial importance to the Association of a large annual meeting is thus clearly seen.

The fact that a positive balance has been achieved is due in no small measure to the enthusiasm and generosity of the people of Dundee and to the loyal and self-denying hard work of our staff, to whom the Association owes a great debt of gratitude.

It will be noticed that a charge for the administration of special funds has been introduced, and that £156 has been credited to general account under this heading.

Although, as far as can be foreseen, any surplus on general account must be hard-won and always dependent on regular maintenance of membership subscriptions, the condition of the general account, regarded separately, would give no cause for anxiety were it not for two matters. Income and Expenditure are so nicely balanced that no considerable extension of the activities of the Association in the service of Science can be undertaken that cannot be made more or less self-supporting financially. In the past, the Association has, to its credit, launched many projects which were not at once remunerative and which subsequently proved of inestimable value. The ability of the Association to continue this function is now severely limited.

Further, the general account must be regarded side by side with the account for Down House which shows an excess of expenditure over income amounting to £1,115 for the year. The debit balance of £1,408 2*s*. 9*d*. in the Suspense Account represents the net excess of expenditure over income from all sources from 1933 to 1948 and is additional to £3,601 17*s*. 1*d*. written off against the general funds of the Association from 1928–33. Since 1928 the total expenditure on Down House has exceeded income from endowment investments, rent, etc., by £7,000 which has been met by grants of £900 from the Pilgrim Trust and contributions and loans from funds at the disposal of the Association. The resolution of this difficult financial problem is engaging the very active consideration of the Council, with the aim of avoiding the continual heavy load on the funds which the Association has gradually accumulated for its general purposes.

It had been hoped that, in spite of unpropitious general economic conditions, the Association's Development Fund Appeal, launched last year, would have attracted additional financial support sufficient to enlarge the Association's opportunity in various directions stated in the appeal and to ensure the proper maintenance of Down House as a memorial to Darwin. A generous contribution of £5,000 has been received from the Pilgrim Trust, the local executive committee for the Dundee Meeting have given £100 from the local fund raised for the meeting, and gifts from members have included amounts of £250, £100 and £50, besides smaller amounts. All these gifts, large and small, have been gratefully received. The fund at present amounts to £5,750, and the appeal to members and others who may be able to help is therefore renewed in the hope that the more ample funds which the Association urgently requires for the extension of its work may be secured.

An agreement with the Royal Society of London, negotiations for which were in progress at the date of the present balance sheet, will result during 1948–49 in the transfer to the Society of the Association's responsibility for the work of its Committee for the Calculation of Mathematical Tables, together with the liabilities and assets appropriate to this Committee, including the balances of the Cunningham Bequest and the Mathematical Tables Fund. The Council have paid tribute in their report (para. 20) to the work of the Committee which has now outgrown the ability of the Association to support it on an adequate scale. It is confidently hoped that the work will continue to prosper and grow under the new auspices.

In conclusion, the year's financial working provides evidence of the virility of the Association. The attendance at the Dundee Meeting and at other conferences arranged by the Association show the demand which exists for the services of the Association, and one may look forward, with greater confidence than last year, to the recovery of the finances of the Association from the effects of the war.

M. G. BENNETT,
General Treasurer.

Balance Sheet, 31st March, 1948

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

LIABILITIES

	£ s. d.	£ s. d.
GENERAL PURPOSES :—		
Sundry Creditors	754 13 1	
Amounts received in advance for publications	105 4 8	
Membership and Associateship subscriptions in advance	76 4 0	
		936 1 9
Accumulated Fund		
As per last Account	19,213 8 0	
Add Funds for general purposes transferred to Accumulated Fund (see Schedule No. 1, appended)	22,955 1 7	
Add Excess of Income over Expenditure for the year, on General Account	614 15 10	
		42,783 5 5
Life Membership Compositions		
As per last Account	5,635 2 2	
Add Subscriptions received during year	393 15 0	
	6,028 17 2	
Less Amount transferred to Income and Expenditure Account	212 10 0	
		5,816 7 2
[48,511 18 8]		49,535 14 4
Development Fund		
Contributions	5,750 3 8	
Add Interest on Investment	20 15 3	
	5,770 18 11	
Less Cost of Printing 19 0 0		
Administration 1 15 3	20 15 3	
- - -]		5,750 3 8
SPECIAL PURPOSES :—		
Caird Fund		
Capital as per last Account	9,928 17 9	
Income and Expenditure Account balance as per last Account 436 6 10		
Add Excess of Income over Expenditure for the year 74 11 6		
	510 18 4	
10,365 4 7]		10,439 16 1
Mathematical Tables Fund		
As per last Account	251 5 9	
Add Receipts from sales	68 11 11	
[251 5 9]		319 17 8
Cunningham Bequest Fund		
As per last Account	1,931 16 2	
Less Excess of Expenditure over Income for the year	18 0	
[1,931 16 2]		1,930 18 2
Toronto University Presentation Fund		
Capital	178 11 4	
Income and Expenditure Account balance as per last Account 35 0 0		
Less Excess of Expenditure over Income for the year 29 12 3		
	5 7 9	
[213 11 4]		183 19 1
Bernard Hobson Fund		
Capital	1,093 2 6	
Income and Expenditure Account balance as per last Account 170 11 8		
Add Excess of Income over Expenditure for the year 30 5 7		
	200 17 3	
[1,263 14 2]		1,293 19 9
Leicester and Leicestershire Fund, 1933		
Capital	1,000 0 0	
Income and Expenditure Account balance as per last Account 74 9 2		
Add Excess of Income over Expenditure for the year 30 15 9		
	105 4 11	
[1,074 9 2]		1,105 4 11
63,611 19 10 Carried forward		70,559 13 8

ASSETS

	£ s. d.	£ s. d.
GENERAL PURPOSES :—		
Investments as scheduled with Income and Expenditure Account, No. 1	47,779 13 9	
Sundry debtors	159 7 9	
Cash in hand	5 16 0	
Cash at bank	53 17 9	
Expenditure on Down House Account	1,536 19 1	
[48,511 18 8]		49,535 14 4
Development Fund		
Investments as scheduled with Income and Expenditure Account, No. 2	5,500 0 0	
Cash at bank	250 3 8	
[- - -]		5,750 3 8
SPECIAL PURPOSES :—		
Caird Fund		
Investments (see Income and Expenditure Account, No. 3)	9,928 17 9	
Cash at bank	510 18 4	
[10,365 4 7]		10,439 16 1
Mathematical Tables Fund		
Cash at bank		319 17 8
[251 5 9]		
Cunningham Bequest Fund		
Investments (see Income and Expenditure Account, No. 4)	1,756 3 7	
Cash at bank	174 14 7	
[1,931 16 2]		1,930 18 2
Toronto University Presentation Fund		
Investment (see Income and Expenditure Account, No. 5)	178 11 4	
Cash at bank	5 7 9	
[213 11 4]		183 19 1
Bernard Hobson Fund		
Investments (see Income and Expenditure Account, No. 6)	1,243 2 6	
Cash at bank	50 17 3	
[1,263 14 2]		1,293 19 9
Leicester and Leicestershire Fund, 1933,		
Investments (see Income and Expenditure Account, No. 7)	1,000 0 0	
Cash at bank	105 4 11	
[1,074 9 2]		1,105 4 11
[63,611 19 10] Carried forward		70,559 13 8

Balance Sheet, 31st March, 1948 (*continued*)

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

LIABILITIES (*continued*)

		£ s. d.	£ s. d.
[*63,611 19 10*]	Brought forward		70,559 13 8
	Radford Mather Lecture Fund		
	Capital	250 0 0	
	Income and Expenditure Account balance as per last Account	44 7 3	
	Less Excess of Expenditure over Income for the year	14 5 7	
		30 1 8	
[*294 7 3*]			280 1 8
	Mrs. E. M. Musgrave's Legacy (1944)		
	Balance as per last Account	75 0 0	
	Less Grant (see Schedule No. 2, appended)	50 0 0	
[*75 0 0*]			25 0 0
	Arthur Haydock Bequest (1945)		
	Capital	2,215 12	
	Income and Expenditure Account balance as per Last Account	74 19 7	
	Add Excess of Income over Expenditure for the year	97 2 2	
		172 1 9	
[*2,290 11 7*]			2,387 13 9
	Gift (1946) for research in memory of Miss J. R. Corcoran		100 0 0
[*100 0 0*]			
	Down House		
	Endowment Fund as per last Account	21,296 9 5	
	Library Fund	10 10 0	
	Sundry Creditors	9 0 1	
	Cash owing to General Account	1,536 19 1	
[*21,693 6 10*]			22,852 18 7
[*88,065 5 6*]			£96,205 7 8

ASSETS (*continued*)

		£ s. d.	£ s. d.
[*63,611 19 10*]	Brought forward		70,559 13 8
	Radford Mather Lecture Fund		
	Investment (see Income and Expenditure Account, No. 8)	250 0 0	
	Cash at bank	30 1 8	
[*294 7 3*]			280 1 8
	Mrs. E. M. Musgrave's Legacy		
	Cash at bank		25 0 0
[*75 0 0*]			
	Arthur Haydock Bequest		
	Investment (see Income and Expenditure Account, No. 9)	2,215 12 0	
	Cash at bank	172 1 9	
[*2,290 11 7*]			2,387 13 9
	Gift for research in memory of Miss J. R. Corcoran—Cash at bank		100 0 0
[*100 0 0*]			
	Down House		
	Investments (see Income and Expenditure Account, No. 10)	21,296 9 5	
	Sundry Debtors	21 14 11	
	Catalogues in stock, at cost	66 8 8	
	Cash at bank, Nil (see opposite)	– – –	
	Cash in hand	60 2 10	
	Suspense Account balance (Excess of Expenditure over Income) as per last Account	292 16 10	
	Add Excess of Expenditure over Income for the year	1,115 5 11	
		1,408 2 9*	
[*21,693 6 10*]			22,852 18 7
[*88,065 5 6*]			£96,205 7 8

We have examined the foregoing Account with the Books and Vouchers and certify the same to be correct. We have also verified the Balance at the Bankers and the Investments, and have inspected the Deeds of Down House.

Approved:
EZER GRIFFITHS
ROBERT S. WHIPPLE } *Auditors.*

W. B. KEEN & CO., *Chartered Accountants*,
Finsbury Circus House, E.C.2
13th July, 1948

INCOME AND EXPENDITURE ACCOUNTS FOR THE YEAR ENDED 31st MARCH, 1948

No. 1. General Income and Expenditure

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£3,886 8*s.* 2*d.* Consolidated 2½ per cent. Stock (Inscribed)	2,901 3 0
	£1,252 16*s.* 2*d.* Consolidated 2½ per cent. Stock (Registered)	1,000 0 0
	£3,268 19*s.* 0*d.* 3 per cent. Savings Bonds 1955/65	3,268 19 0
	£1,000 0*s.* 0*d.* 3 per cent. Savings Bonds 1960/70	1,000 0 0
	£18,300 0*s.* 0*d.* 3 per cent. Savings Bonds, 1965/75	18,998 11 9
	£879 14*s.* 9*d.* Great Indian Peninsula Railway 'B' Annuity, £43	827 15 0
	£52 12*s.* 7*d.* 3½ per cent. War Stock (Post Office issue)	54 5 2
	£7,370 19*s.* 6*d.* 3½ per cent. War Stock, 1952 or after	7,482 10 9
	£6,368 15*s.* 7*d.* 3½ per cent. Conversion Stock, 1961 or after	5,304 8 11
	£4,184 18*s.* 2*d.* 2½ per cent. Treasury Stock, 1975 or after	4,184 18 2
	£1,000 0*s.* 0*d.* 4 per cent. Funding Loan Stock, 1960/90	1,170 0 0
	£454 11*s.* 6*d.* 3 per cent. London County Consolidated Stock, 1956/61	462 2 0
	£981 10*s.* 0*d.* 4 per cent. Commonwealth of Australia Stock 1955/70	1,000 0 0
	£125 3*s.* 9*d.* 3 per cent. British Transport Stock, 1978/88	125 0 0
	[*Value of stocks at 31/3/47, £52,285 4s. 8d.*] (Value at 31/3/48, £48,651 6*s.* 8*d.*)	
[*47,779 13 9*]		£47,779 13 9

	EXPENDITURE	£ s. d.	£ s. d.
	To Heat, Lighting and Power		60 10 4
	„ Stationery		268 3 2
	„ Rent		1 0 0
	„ Postages		268 3 0
	„ Telephone		35 0 7
	„ Insurances		13 12 5
	„ Travelling expenses		510 5 1
	„ Audit for 1946–47		42 0 0
	„ Exhibitioners		126 1 10
	„ Subscription to Parliamentary and Scientific Committee		10 10 0
	„ Hire of meeting rooms, etc.		36 3 10
	„ Reporting of Conferences, and copying, etc., by outside offices		69 15 4
	„ Lift Inspection and Repairs		25 12 0
	„ Carriage		15 17 1
	„ Reference books, press cuttings, etc.		46 14 1
	„ General expenses		35 3 1
	„ Panels of armorial bearings		19 0 6
	„ Salaries, wages, pensions and National Insurance		3,019 6 4
	„ Printing, etc.—		
	"The Advancement of Science"	1,322 16 8	
	Miscellaneous	859 4 8	2,182 1 4
	„ Alexander Pedler Lecture, 1947 :		
	Fee	10 10 0	
	Press advertisement	2 8 0	12 18 0
	„ Norman Lockyer Lecture, 1947 :		
	Fee		10 10 0
	„ Hospitality		12 19 11
[*4,456 3 11*]			6,821 7 11
	„ Balance, being excess of Income over Expenditure for the year, transferred to Acccumulated Fund		614 15 10
[– – –]			
[*4,456 3 11*]			£7,436 3 9

	INCOME	£ s. d.	£ s. d.
	By Annual subscriptions		3,899 12 5
	„ Life Compositions : amount transferred on expiry of membership		212 10 0
	„ Sale of Publications	666 10 4	
	Less amount transferred to Mathematical Tables Fund	68 11 11	597 18 5
	„ Advertisements in B.A. publications		817 2 8
	„ Income Tax recovered to 31st March, 1947		279 3 10
	„ Interest on Investments		1,473 0 7
	„ Charges for administration of Special Funds		156 15 10
[*4,136 2 9*]			7,436 3 9
	By Balance, being excess of Expenditure over Income for the year		– –
[*320 1 2*]			
[*4,456 3 11*]			£7,436 3 9

No. 2. Development Fund

An appeal for a Development Fund, to be used under the direction of the Council, was made at the Annual Meeting at Dundee in 1947. The fund is still open.

		£ s. d.
	Investments at cost :	
	£2,745 19*s.* 0*d.* London County 2½ per cent. Consolidated Stock, 1960/70	2,750 0 0
	£2,679 1*s.* 6*d.* Bristol Corporation 3 per cent. Redeemable Stock, 1958/63	2,750 0 0
	(Value at 31/3/48, £5,342 2*s.* 7*d.*)	
[– – –]		£5,500 0 0
	Cash at bank	£250 3 8

No. 2. Development Fund (*continued*)

EXPENDITURE	£ s. d.	INCOME	£ s. d.
To Cost of Investments	5,500 0 0	By Contributions	5,750 3 8
„ Printing	19 0 0	„ Interest	20 15 3
„ Administration	1 15 3		
„ Balance, cash at bank, transferred to balance sheet	250 3 8		
[– – –]	£5,770 18 11	[– – –]	£5,770 18 11

No. 3. Caird Fund

The unconditional gift of Sir James Caird, in 1912, administered by the Council in accordance with recommendations adopted by the General Committee in 1913.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

	£ s. d.	
Investments at cost :		
£2,627 0*s.* 10*d.* 3 per cent. Savings Bonds 'A,' 1960/70	2,627 0 10	
£2,716 16*s.* 6*d.* 3½ per cent. War Loan Inscribed Stock	2,516 15 5	
£4,282 18*s.* 9*d.* 3 per cent. British Transport Stock, 1978/88	4,785 1 6	
[*Value of stocks at 31/3/47, £9,725 8s. 11d.*] (Value at 31/3/48, £9,613 6*s.* 7*d.*)		
[*9,928 17 9*]	£9,928 17 9	
Cash at bank	£510 18 4	

EXPENDITURE	£ s. d.	£ s. d.	INCOME	£ s. d.	£ s. d.
To Grants (see Schedule No. 2)	201 19 9		By Dividends and Interest	224 9 10	
„ Administration charge	30 14 7		„ Income Tax recovered	82 16 6	
[*597 1 9*]	232 14 4		[*367 1 10*]		307 5 10
„ Balance, being excess of Income over Expenditure for the year	74 11 6		*By Balance, being excess of Expenditure over Income for the year*		– – –
[– – –]			[*229 19 11*]		
[*597 1 9*]	£307 5 10		[*597 1 9*]		£307 5 10
Grants authorised, not yet drawn :—					
Mathematical Tables	100 0 0				
Zoological Record	50 0 0				
Biology in the School Curriculum	5 0 0				
Naples Zoological Station	50 0 0				
National Atlas	10 0 0				
Geographical Terminology	5 0 0				
Urban Geography	3 0 0				
Revival of Geography	5 0 0				
Kent's Cavern	5 0 0				
Demography in Inter-Tropical Africa	5 0 0				
Derbyshire Caves	25 0 0				
Notes and Queries on Anthropology	25 0 0				
[*227 9 9*]	£288 0 0				

No. 4. Cunningham Bequest

A legacy received by the Association in 1929 in trust under the will of Lt.-Col. A. J. C. Cunningham, for the preparation of new mathematical tables in the theory of numbers ; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

	£ s. d.	
Investments at cost :		
£1,187 6*s.* 10*d.* Consolidated 2½ per cent. Stock (Inscribed)	653 0 9	
£178 16*s.* 5*d.* Consolidated 2½ per cent. Stock (Registered)	150 0 0	
£300 0*s.* 0*d.* Port of London 3½ per cent. Stock 1949/99	216 0 0	
£737 2*s.* 10*d.* 2½ per cent. Treasury Stock, 1975 or after	737 2 10	
[*Value of stocks at 31/3/47, £2,315 6s. 9d.*] (Value at 31/3/48, £1,913 17*s.* 5*d.*)		
[*1,756 3 7*]	£1,756 3 7	
Cash at bank	174 14 7	

EXPENDITURE	£ s. d.	£ s. d.	INCOME	£ s. d.	£ s. d.
To Grants (see Schedule No. 2)	54 18 6		By Dividends and Interest	53 9 7	
„ Administration charge	6 0 0		„ Income Tax recovered	6 10 11	
[– – –]	60 18 6		[*66 11 9*]		60 0 6
To Balance, being excess of Income over Expenditure for the year	– – –		By Balance, being excess of Expenditure over Income for the year		18 0
[*66 11 9*]					
[*66 11 9*]	£60 18 6		[*66 11 9*]		£60 18 6
Grant authorised, not yet drawn :—					
Mathematical Tables	£50 0 0				
[*50 0 0*]	£50 0 0				

No. 5. Toronto University Presentation Fund

A fund voluntarily subscribed by members present at the Toronto Meeting in 1924. From the income a presentation of two bronze medals each year is made, together with presents of books, to selected students in pure and applied science respectively.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£175 0s. 0d. 3½ per cent. War Stock . . .	178 11 4
[*Value of stock at 31/3/47,* £186 7s. 6d.]	(Value at 31/3/48, £181 11s. 3d.)	
£178 11s. 4d.]		£178 11 4
	Cash at bank	£5 7 9

EXPENDITURE	£ s. d.	INCOME	£ s. d.
To Cost of medals for 1943–47	11 17 6	By Interest	6 2 6
„ Presents of books, through Toronto University .	23 5 0	[6 2 6]	
„ Administration charge	12 3	By Balance, being excess of Expenditure over Income for the year	29 12 3
[- - -]	35 14 9	[- - -]	
To Balance, being Income for the year	- - -		
[6 2 6]			
[6 2 6]	£35 14 9	[6 2 6]	£35 14 9

No. 6. Bernard Hobson Fund

The bequest of Mr. Bernard Hobson, 1933; the income to be applied to the promotion of geological research; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£50 0s. 0d. 4 per cent. Victory Bonds . .	55 10 5
	£601 9s. 0d. 2½ per cent. Treasury Stock, 1975 or after	601 9 0
	£416 0s. 11d. 3½ per cent. War Stock (Inscribed) .	436 3 1
	£178 16s. 4d. Consolidated 2½ per cent. Stock (Registered)	150 0 0
[*Value of stocks at 31/3/47,* £1,250 4s 11d.]	(Value at 31/3/48, £1,085 11s. 0d.)	
[1,243 2 6]		£1,243 2 6
	Cash at bank	£50 17 3

EXPENDITURE	£ s. d.	INCOME	£ s. d.
To Grants	- - -	By Interest	32 1 8
„ Administration charge	3 7 3	„ Income Tax recovered	1 11 2
[100 0 0]	3 7 3	[38 12 8]	33 12 10
„ Balance, being Excess of Income over Expenditure for the year	30 5 7	„ *Balance, being Excess of Expenditure over Income for the year*	- - -
[- - -]		[61 7 4]	
[100 0 0]	£33 12 10	[100 0 0]	£33 12 10
Grant authorised, not yet drawn :— Critical Geological Sections	£20 0 0		
[5 0 0]	£20 0 0		

No. 7. Leicester and Leicestershire Fund, 1933

The unexpended balance of the local fund for the Leicester Meeting in 1933, presented to the Association, the interest to be used in assisting by scholarships or otherwise students working for the advancement of science; administered by the Council.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£487 2s. 11d. 3½ per cent. Conversion Stock .	500 0 0
	£490 5s. 11d. 3½ per cent. War Stock . .	500 0 0
[*Value of stocks at 31/3/47,* £1,062 18s. 1d.]	(Value at 31/3/48, £1,017 15s. 0d.)	
[1,000 0 0]		£1,000 0 0
	Cash at bank	£105 4 11

EXPENDITURE	£ s. d.	INCOME	£ s. d.
To Administration charge	3 8 5	By Interest	34 4 2
[- - -]		[34 4 2]	
„ Balance, being Excess of Income over Expenditure for the year	30 15 9		
[34 4 2]			
[34 4 2]	£34 4 2	[34 4 2]	£34 4 2

No. 8. Radford Mather Lecture Fund

A gift of £250 received from Mr. G. Radford Mather in 1936 to establish a Fund, the income therefrom to be devoted to meeting the expense of triennial Lectures on Recent Advances in Science and their relation to the Welfare of the Community.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investment at cost :	
	£248 17*s.* 8*d.* 3 per cent. London County Consolidated Stock, 1956/61	250 0 0
[*Value of stock at 31/3/47, £262 11s. 4d.*]	(Value at 31/3/48, £257 11*s.* 11*d.*)	
[*250 0 0*]		£250 0 0
	Cash at bank	£30 1 8

EXPENDITURE

	£ s. d.
To Lecture fee	21 0 0
„ Administration charge	14 11
[– – –]	21 14 11
„ *Balance, being Excess of Income over Expenditure for the year*	– – –
[*7 9 4*]	
[*7 9 4*]	£21 14 11

INCOME

	£ s. d.
By Interest [*7 9 4*]	7 9 4
„ Balance, being Excess of Expenditure over Income for the year [– – –]	14 5 7
[*7 9 4*]	£21 14 11

No. 9. Arthur Haydock Bequest

A bequest received in 1945 "for the purpose of original investigation of problems relating to either or both of Geology or Botany as may be determined by the governing body of the British Association."

		£ s. d.
	Investment, as received :	
	£2,090 4*s.* 0*d.* 3½ per cent. Conversion Stock (Registered)	2,215 12 0
[*Value of Stock at 31/3/47, £2,320 2s. 5d.*]	(Value at 31/3/48, £2,184 5*s.* 2*d.*	
[*2,215 12 0*]		£2,215 12 0
	Cash at bank	£172 1 9

EXPENDITURE

	£ s. d.
To Administration charge	10 15 9
[– – –]	
„ Balance, being Excess of Income over Expenditure for the year	97 2 2
[*56 13 10*]	
[*56 13 10*]	£107 17 11

Grant authorised, not yet paid :—

Cytology and Genetics	£5 0 0
[– – –]	£5 0 0

INCOME

	£ s. d.
By Interest	73 3 0
„ Income Tax recovered	34 14 11
[*56 13 10*]	£107 17 11

No. 10. Down House

In response to an appeal made in 1927 by Sir Arthur Keith, F.R.S., then President of the British Association, Mr. (later Sir) Buckston Browne, F.R.C.S., acquired the property of Down House, formerly the home of Darwin, and transferred it with an endowment of £20,000 to the Association expressing the wish that it be held in custody for the nation as a memorial to Darwin.

(Figures in italic type and square brackets, to the left of columns, are those of the preceding year's account, inserted for comparison.)

		£ s. d.
	Investments at cost :	
	£3,000 Fishguard and Rosslare Railway and Harbours 3½ per cent. Guaranteed Preference Stock	2,139 17 3
	£7,944 2*s.* 4*d.* Consolidated 2½ per cent. Stock (Inscribed)	6,206 15 0
	£5,971 16*s.* 11*d.* Consolidated 2½ per cent. Stock (Registered)	5,000 0 0
	£2,444 15*s.* 10*d.* 3 per cent. Redemption Stock, 1986/96 (Registered)	2,500 0 0
	£7,380 9*s.* 9*d.* 3 per cent. British Transport Stock, 1978/88	5,449 17 2
[*Value of stocks at 31/3/47, £26,026 2s. 5d.*]	(Value at 31/3/48, £23,149 0*s.* 5*d.*)	
[*21,296 9 5*]		£21,296 9 5

No. 10. Down House (*continued*)

EXPENDITURE	£	s.	d.	INCOME	£	s.	d.
To Wages of Staff	1,074	10	6	By Rents receivable	88	2	6
„ Rates, Insurance, etc.	104	16	9	„ Income Tax recovered	254	9	9
„ Electricity	62	5	5	„ Dividends and Interest	625	16	10
„ Fuel, etc.	114	10	7	„ Sale of catalogues, postcards and photographs	23	1	9
„ Drainage	25	1	1	„ Donations received	2	3	8
„ Water	19	15	9	„ Caird Fund: grant for Seismology	10	0	0
„ Repairs and Renewals (including hot water boiler, radiators and entrance gates)	429	14	6	[*1,174 15 9*]	1,003	14	6
„ Land and Garden: materials and maintenance	112	6	3	„ Balance, being Excess of Expenditure over income for the year	1,115	5	11
„ Donations to village institutions	5	5	0	[*474 12 3*]			
„ Household requisites, etc.	18	12	2				
„ Carriage		15	1				
„ Printing, postage, telephone, stationery	35	7	10				
„ Seismology (see opposite)	16	12	1				
„ Administration charge	99	7	5				
[*1,649 8 0*]	£2,119	0	5	[*1,649 8 0*]	£2,119	0	5

Schedule No. 1

The following funds standing separately in the Balance Sheet at March 31, 1947, were, by the Council's resolution of February 6, 1948, transferred to the Accumulated Fund. It is noted that upon receipt of the British Science Guild's Capital Fund in 1936 the Association undertook to maintain the Norman Lockyer and Alexander Pedler Memorial Lectures established by the Guild before its incorporation with the Association.

	£	s.	d.
Hon. Sir Charles Parsons' gift (1922) and legacy (1934)	12,000	0	0
Sir Alfred Ewing's legacy (1935)	500	0	0
Dr. C. D. Sherborn's legacy (1943)	500	0	0
Lady Mary Lockyer's legacy (1944)	1,000	0	0
Dr. F. W. Aston's legacy (1946)	1,000	0	0
British Science Guild: Capital Fund (1936)	3,431	9	1
Grants Equalisation Fund	2,085	5	10
Contingency Fund	1,657	2	9
Overseas Delegations Fund	781	3	11
	£22,955	1	7

Schedule No. 2

Grants paid to Research Committees, etc., during the financial year to March 31, 1948.

NOTE.—The year indicated in brackets after the title of each committee is that of its original appointment, and the sum if any, is that previously expended out of grants by the Association.

	£	s.	d.	£	s.	d.
1. Paid out of the Caird Fund (1912)						
Plymouth Laboratory (1886: £1,848 10*s.* 8*d.*)	50	0	0			
Zoological Record (1923: £1,135)	50	0	0			
Mathematical Tables*	77	9	9			
Derbyshire Caves (1921: £396 5*s.* 8*d.*)	12	10	0			
Urban Geography (1947)	2	0	0			
Down House: for Seismology	10	0	0			
				201	19	9
2. Paid out of the Cunningham Bequest (1929)						
Mathematical Tables*				54	18	6
3. Paid out of Mrs. E. M. Musgrave's Legacy (1944)						
Freshwater Biological Station (1930: £1,237 15*s.* 11*d.*)				50	0	0
				£306	18	3

*Mathematical Tables (1913)

Total grants paid to March 31, 1948:—

	£	s.	d.	£	s.	d.
From Cunningham Bequest	2,895	9	5			
„ Caird Fund	1,721	19	8			
„ Mathematical Tables Fund	192	16	0			
„ General Fund	415	17	6			
„ Royal Society Grant (1933)	50	0	0			
				£5,276	2	7
Amount recovered by sale of tables, etc.:						
As last year	931	14	4			
Add for year to 31/3/48	164	14	8			
				1,096	9	0
				£4,179	13	7

INDEX to Volume V, 1948–1949

Figures in heavy type preceding page references indicate the parts of *The Advancement of Science* in which references will be found.

Titles of communications are frequently abbreviated.

Abilities, changes in, by Dr. P. E. Vernon, **18,** 138
Aboriginal problem in Hyderabad, by Prof. C. von Fürer-Haimendorf, **17,** 53
Administrator and teacher, Discussion on, **20,** 352
Administration of large-scale enterprises, by J. C. Picton, **20,** 350
Adolescent and the cinema, Discussion on, **20,** 351
African fresh-water fisheries, by Miss R. Lowe, **20,** 349
African land tenure, by Dr. L. P. Mair, **17,** 51
Agriculture and world food problem, by Dr. G. Scott Robertson, **19,** 277
ALEXANDER, Dr. W. P., Unesco, **20,** 352
Algebraic geometry, by Dr. D. Pedoe, **20,** 348
ALLEN, D. N. de G., Applicable mathematics, **20,** 350, 354
American Association, **20,** 316, 358
ANDERSON, F. R., Mechanisation of collieries, **17,** 44
Animal colouration, by Dr. M. G. M. Pryor, **20,** 349
Anthropology, psychology, and sociology, by Prof. T. H. Pear, **20,** 351
APPLETON, Sir Edward, Coal as a source of heat and power, **17,** 39, 45
Applicable mathematics, Joint discussion on, **20,** 350
Arenicola marina L., by G. P. Wells, **20,** 349
ARMSTRONG, A. L., Rock-shelters of the Creswell group, **20,** 350
Arran intrusions, by M. V. N. Murthy and M. S. Rao, **20,** 349
ASTBURY, N. F., Anistropic silicon iron, **20,** 348
AUSTIN, Mrs. F. M., Psychological control of fear, **20,** 351

BAGNOLD, Brig. R. A., Sand and waves, **20,** 348, 353
BAKER, Dr. H. G., Gene-flow between inter-fertile species, **20,** 352
BALCHIN, N., Incentives, **20,** 351, 354
Ballydun, by J. M. Mogey, **20,** 349
Baltic ports, pre-war hinterlands of, by F. W. Morgan, **20,** 350
BARBER, N. F., Theories of coastal waves, **20,** 348
Barlow Report, Discussion at Conference on Universities in the community, **17,** 4
Barnacle, anatomy of, by Prof. H. G. Cannon, **20,** 349
BARNARD, Prof. G. A., Design of a sampling inspection scheme, **20,** 350
Barotse law, concept of reasonable man, by Dr. M. Gluckman, **20,** 350
BATEMAN, Dr. A. J., Structure of populations of cultivated plants, **20,** 352, 355
BATHAM, Miss E. J., Metridium, **20,** 349
BELOE, R., Visual aids to education, **20,** 352, 355
BERNAL, Prof. J. D., Coal economy in domestic heating, **17,** 46; Conservation of elements, **20,** 335, 348; Research in Universities, **17,** 15
BEWLEY, Dr. W. F., Control of heat and light in glasshouses, **20,** 353, 355
BICKLEY, Prof. W. G., Applicable mathematics, **20,** 350, 354
Biochemical applications of isotopes, by Dr. A. S. McFarlane, **18,** 86
Biology in educational curriculum, Discussion on, **20,** 349
BIRLEY, R., Reconstruction of education in Germany, **20,** 352, 355
BLACKETT, Prof. P. M. S., Implications of the Barlow Report, **17,** 4; Operational Research, **17,** 26
BLAXTER, Dr. K. L., Endocrine treatment of dairy cattle, **20,** 351
Blood groups, Report of a discussion on, **20,** 305
BONHAM, H. J., Modern school biology, **20,** 349
BOWEN, Prof. I., Building materials supply, **20,** 350, 354
BOWIE, Dr. J. A., Incentives, **18,** 119
BRAGG, Sir Lawrence, Crystalline state, **19,** 165
BRAY, F., Young worker in industry, **20,** 352
BRICE, W. C., Early pottery in S.E. Turkey, **20,** 351, 354
Brighton, Geology of, by Dr. J. F. Kirkaldy, **20,** 348; Growth of, by E. W. Gilbert, **20,** 349; Meeting at, 1948, **20,** 283; Short history of, by H. D. Roberts, **18,** 75
BRIMELOW, E. I., Aluminium alloys in building, **20,** 348, 353
British Council, **20,** 359
BROOKS, Prof. F. T., Economic importance of fungi, **20,** 329; Forestry and the community, **20,** 296, 352
BROWN, Prof. A. J., Some aspects of inflation, **20,** 350
BROWN, J. M. B., Beech cultivation, **20,** 352
BROWNE, Prof. R. E., Working conditions in the mines, **17,** 44
BUCKLEY, L. R., Administrator and teacher, **20,** 352
Building, Symposium on new materials, **20,** 348, 353
Building materials supply, by Prof. I. Bowen, **20,** 350, 354
BULL, Dr. A. J., Nivation in S. Downs, **20,** 350
BULLEID, O. V. S., Railway locomotive developments, **20,** 350, 354
Bureau of Scientific Information, **20,** 361
BURGERS, Prof. W. G., Twins in recrystallised metals, **20,** 348, 353
BUSH, R., Frost and the fruitgrower, **20,** 353

CANNON, Prof. H. G., Anatomy of barnacle, **20,** 349, 353; Biology in education, **20,** 349; Undergraduate zoology, **19,** 194
Capital investment, by F. W. Paish, **20,** 350
CARLING, Sir E. Rock, Problems of old age, **20,** 351
CARLISLE, S. S., Electronics in steel industry, **20,** 348, 353
CARTER, Dr. G. S., Biology of colour vision, **20,** 349, 353
CAVE-BROWNE-CAVE, Wing-Cdr. T. R., Young Engineer, **19,** 218
CHAPMAN, D., Harmony in working groups, **18,** 120; Incentives, **18,** 109
CHAPMAN, Prof. S., Magnetic fields, **20,** 348, 353
CHASTON, Dr. J. C., Rare metals in industry, **20,** 348
Chemical resources of Scotland, Discussion on, **17,** 20
Chemistry, specialisation and culture, by Prof. J. Read, **19,** 175
Children's interest in team games, by J. R. Clarke, **18,** 139
CHURCH, Dr. R. J. H., Colonial development, **20,** 349
CLARK, J. R., Children's interest in team games, **18,** 139
CLARK, Prof. W. E. Le G., Miocene apes, **20,** 340, 350
CLARKE, Sir Fred, Administrator and teacher, **20,** 352, 355
Coal, as a chemical raw material, by Dr. R. Holroyd, **17,** 43; as a source of heat and power, by Sir Edward Appleton, **17,** 39, 45; Combustion of, by Prof. H. L. Riley, **17,** 46; Evidence of development, by Dr. A. C. Seyler, **17,** 41; Future of supplies, by Prof. H. G. A. Hickling, **17,** 40; Supply and utilisation of, **17,** 38; Survey of resources, by Dr. A. C. Monkhouse, **17,** 41
Coalfields, Prospects of discovering new, by Dr. G. M. Lees, **17,** 43
Coal-mines, Working conditions in, by Dr. C. L. Cope, **18,** 99
Coastal waves, Symposium on, **20,** 348
COHEN, Miss R., Economic factors affecting food supply, **20,** 350
Colonial development, Discussion on Scientific aspects, **20,** 349; by Sir F. Stockdale, **20,** 300
Colonial fisheries, by Dr. C. F. Hickling, **20,** 349
Colour perception in animals, by Dr. R. J. Pumphrey, **20,** 349
Colour vision, by Prof. H. Hartridge, **19,** 243; Biology of, by Dr. G. S. Carter, **20,** 349; Discussion on, **20,** 351; Varieties of, by Dr. R. W. Pickford, **20,** 349
Community, Place of Universities in, **17,** 4
Computation, Report on modern methods, **18,** 79
Conference of Delegates of Corresponding Societies, **17,** 56; **20,** 317
Conservation of the chemical elements, Discussion on, **20,** 335, 348
COPE, Dr. C. L., Working conditions in coal mines, **18,** 99
Coppice management, Joint discussion on, **20,** 352
CORDINGLEY, Prof. R. A., English rural dwelling types, **20,** 350
Corresponding Societies, Conference of delegates, **17,** 56; **20,** 317; and the communities they serve, by Prof. H. J. Fleure, **20,** 317
Cosmic magnetism, Symposium on, **20,** 348
Cotton pests in Africa, by Dr. R. Rainey, **20,** 349
Council Membership, 1948-49, **20,** 359
Council's Report to General Committee, **20,** 358
Crawling of worms, by Dr. G. Newell, **20,** 349
CROSBY, J. L., Intrapopulation heterogeneity and breeding range, **20,** 352
CROWTHER, D. J., Industrial education and training during the war, **20,** 352
Crystalline proteins, structure, by Dr. M. F. Perutz, **20,** 348
Crystalline state, by Sir Lawrence Bragg, **19,** 165
Crystals, movements of atoms in, by Mrs. K. Lonsdale, **20,** 348
Cultural change, Report of a colloquium, **17,** 48
CUMMING, Prof. W. M., Chemical industry in Scotland, **17,** 25
CURLE, A., Incentives, **20,** 351, 354
CURWEN, Dr. E. C., N.W. European sickle, **20,** 350, 354

DALE, Sir Henry, Nerve fibres, **20,** 351; Research in Universities, **17,** 11
Dance magic in England, by D. N. Kennedy, **20,** 350
DARLINGTON, Dr. C. D., Blood groups and language, **20,** 309, 351
DAS, M. C., Life-history of Ginanniella primulae and G. trientalis, **20,** 352
DAVIES, J. H., Bulk purchase, **20,** 350
DAVIES, Prof. S. J., Heat pumps, **20,** 350, 354
DAVIS, Miss N. M., Incentives in the building industry, **18,** 122
DEACON, Dr. G. E. R., Coastal waves, **20,** 348
DENNISON, S. R., Industrial productivity, **20,** 350, 354
Depletion of wild animal populations, by Prof. J. Ritchie, **17,** 64
Derbyshire caves, report of a committee, **20,** 356
DESCH, Dr. C. H., Newer metals in industry, **20,** 348
DESMOND, D. J., Accuracy of automatic lathes, **20,** 350, 354
Deterrents, by Dr. A. T. M. Wilson, **18,** 111

Development Fund, **20**, 359
DICKS, Prof. H. V., Personality traits and political ideology, **18**, 134
Diesel engines, by Sir Harry R. Ricardo, **20**, 350
DIGBY, A., Economic organisation among primitive peoples, **20**, 350
Distribution of Industry Act and Development Areas, by Prof. J. Sykes, **20**, 350
DODMAN, N. D., Cinema attendance among adolescents, **20**, 351
DOLLAR, Dr. A. T. J., Jan Mayen Island, **20**, 349
DONALD, Dr. H. P., Inbreeding and cross breeding in livestock, **20**, 353, 355
DÖNMEZ, Bey Ahmet, Early pottery in S.E. Turkey, **20**, 351
Down House, **20**, 362
Dowsing, by P. A. Ongley, **20**, 348
DUDDING, Dr. B. P., Statistical methods and engineering processes, **20**, 350, 354
Dundee, Industrial development of, by Sir Garnet Wilson, **18**, 123
Dundee Trust, **20**, 362
DURANT, H., Public opinion surveys, **18**, 138
Durkheimian society, by Dr. J. G. Peristiany, **20**, 350
Dyke swarm of S. Jersey, by D. L. Searle, **20**, 349

Early agriculture, Discussion on, **20**, 350
EBORALL, R., Non-ferous metals in industry, **20**, 348
Economic analysis, contribution of, in business behaviour, by D. C. Hague, **20**, 350
Economic Crisis, Science in, **20**, 361
Education, changing scope of, by W. O. L. Smith, **19**, 272
EELES, Col. H. S., Coppice management, **20**, 352
Egypt, Post-war economic developments, by A. McL. Frood, **20**, 349
Egypt, predynastic civilisation, by Prof. P. E. Newberry, **20**, 351
Engineer, The young, by Wing-Cdr. T. R. Cave-Browne-Cave, **19**, 218
English rural dwelling types, by Prof. R. A. Cordingley, **20**, 350
Eridu excavations, by Seton Lloyd, **20**, 351
EVANS, K. R., Industrial education and training during the war, **20**, 352
EVANS, P., Geologist in industry, **20**, 349; Photo-geology, **20**, 349
EYSENCK, Dr. H. J., Psychology of anti-semitism, **20**, 351, 354; Public opinion surveys, **18**, 138

Farey Series, by Prof. E. H. Neville, **20**, 348
FARMER, B. H., Colonial development, **20**, 349
Fat supplies, by Prof. T. P. Hilditch, **20**, 322
FAWCETT, Prof. C. B., Population movements, **20**, 349
FELDBERG, Dr. W., Nerve fibres: synaptic transmission, **20**, 351
FELTON, A. L., Coppice management, **20**, 352
Fertilisation of marine areas, by Prof. J. E. G. Raymont, **20**, 349
FIELLER, E. C., Statistical aspects of specification, **20**, 350
Fish, effect of war on, by A. R. Margetts and S. J. Holt, **20**, 349
FISHER, Prof. R. A., Theory of inbreeding, **20**, 353, 355
Fisheries research, Individual in, by E. Ford, **20**, 349
Fishing, theory of, by Dr. M. Graham, **20**, 349
FLEISCH, Prof. A., Nutrition, **20**, 351, 354
FLEMING, Sir Arthur, Industrial education and training during the war, **20**, 352
FLEURE, Prof. H. J., Corresponding Societies and the communities they serve, **20**, 317
Flora, study of British, by Prof. J. R. Matthews, **18**, 262
Folk-life studies, by R. U. Sayce, **19**, 231
Folk-memory in folk tales, by Canon J. A. MacCulloch, **20**, 350
FOLLEY, Dr. S. J., Endocrine and nervous control of lactation, **20**, 351
Fono Manu of Sa'anapu, by J. D. Freeman, **20**, 351
Food, symposium on, **20**, 350
FORD, E., Individual in fisheries research, **20**, 349
Forestry Education, Discussion on, **20**, 352
Forestry, influence on community, by W. L. Taylor and others, **20**, 293, 352
FORTUNE, Dr. R. F., Primitive warfare, **20**, 351
Fossil apes collected by British-Kenya Miocene Expedition, by Prof. W. E. Le Gros Clark, **20**, 350
FOWLER, Dr. F. J., Punjab canal colonies, 20, 349
FOX, Dr. L., Relaxation methods, **18**, 85
FRASER, D. C., Humphrey's paradox, **18**, 133
FROOD, A. McL., Post-war Egypt, **20**, 349
Freedom in science, **20**, 361
FREEMAN, J. D., Fono Manu of Sa'anapu, **20**, 351
FUCHS, Dr. L. G., Training methods for the partially sighted, **20**, 351
FULLER, Miss G. J., Wealdon roads, **20**, 349
Fungi, by Prof. F. T. Brooks, **20**, 329

GABOR, Dr. D., Microscopy by wave-front reconstruction, **20**, 348, 353
GAIRNS, Dr. F. W., Nervous factors in suckling, **20**, 351, 354
Galley Hill skeleton, by Dr. K. P. Oakley, **20**, 350
GARDNER, P. A. D., Peptic ulcer patients, **20**, 351
Genetical structure of plant populations, Symposium on, **20**, 352
General Committee, **20**, 359
Geography as a social science, by Lord Rennell, **19**, 205
Geological map of Gt. Britain, **20**, 361
Geological map, the ideal, by Prof. D. L. Linton, **18**, 141
Geologist, Discussion on training, **20**, 349
Geology and air photography, Discussion on, **20**, 349
Geology in coalfields, by Dr. M. Macgregor, **17**, 40
Geology to-day and to-morrow, by Dr. A. E. Trueman, **19**, 184
GEORGE, Prof. T. N., University geology, **20**, 349
GILBERT, A., New-type examinations in technical education, **20**, 351
GILBERT, E. W., Growth of Brighton, **20**, 349, 354
GIMINGHAM, C. T., Insecticides in agriculture, **18**, 89
GLUCKMAN, Dr. M., Reasonable man in Barotse law, **20**, 350
GOOD, P., Metric system, **20**, 350, 354
GOOD, Prof. R. D'O., Evolution and the flowering plants, **20**, 352
GORER, G., National character, **18**, 133
GOSLING, A. H., Influence of forestry, **20**, 298, 352
GOULD, R., Unesco, **20**, 352
GRAHAM, Prof. A., Molluscan stomach, **20**, 349
GRAHAM, Dr. M., Theory of fishing, **20**, 349
GRIFFITHS, Miss M. V., Domestic fuel economy, electrical aspect, **17**, 47
Groundnut scheme, by A. J. Wakefield, **20**, 349
Guidance in Australia, Development of, by H. S. Williams, **20**, 351
GUNN, Dr. J. L., Aircraft control of locusts, **18**, 92

HAGUE, D. C., Economic analysis in business behaviour, **20**, 350
HARRIS, Dr. A. N., Geomorphology of N.-E. Wales, **20**, 349
HARRIS, Prof. T. M., Teaching of biology, **20**, 349
HARTRIDGE, Prof. H., Colour vision, **19**, 243
HARTSHORN, Dr. L., Metric system, **20**, 350, 354
HASKELL, G. M. L., Hybrid maize, **20**, 353
HAYES, Prof. K. A., Servo-mechanisms, **20**, 348
Heat Pumps, by Prof. S. J. Davies and F. G. Watts, **20**, 350
Heating and ventilation in industry, by Dr. T. Bedford, **18**, 103
HEIM, Prof. R., Life-history of Termitomyces, **20**, 352
HEMPSON, J. G. G., Measurement of stress and pressure, **20**, 350, 354
HENDERSON, A. M., Public enterprise profits and chargings, **20**, 350
HENDERSON, D. M., Life-history of Sclerotinia tuberosa, **20**, 352
HENDERSON, Sir Hubert, The price system, **19**, 210
HENRIQUES, L. F., Pocomania, a Jamaican cult, **20**, 350
HETTINGER, Dr. J. H., Trans-Atlantic telepathy, **18**, 140
HICKLING, Dr. C. F., Colonial fisheries, **20**, 349
HICKLING, Prof. H. G. A., Future of coal supplies, **17**, 40
HILDITCH, Prof. T. P., World fat supplies, **20**, 322, 352
HODGKIN, Mrs. D., Structure of penicillin, **20**, 348, 353
HOLLEYMAN, G. A., Celtic field system in Sussex, **20**, 350
HOLROYD, Dr. R., Coal as a chemical raw material, **17**, 43
HOLT, S. J., Effects of war on N. Sea fish, **20**, 349, 353
Horticulture, control of environment, **20**, 353
HOUSTON, J. M., Village planning in Scotland, **18**, 129
HOWIE, Dr. J. W., Nutrition and infection, **20**, 351, 354
HUGHES, Dr. G. M., Antagonistic reflexes in Arthropods, **20**, 351
Human factors in industry, Report of a Conference, **18**, 96
Human relations in industry, by Alec Rodger, **18**, 116; by Dr. R. F. Tredgold, **18**, 107
Humphrey's paradox, by D. C. Fraser, **18**, 133
HUTTON, Prof. J. H., Cultivation economies in the Naga Hills, **20**, 350
HYDE, Miss M. M., Evolution and the flowering plants, **20**, 352

Inbreeding and hybrid vigour in livestock and crop impovement, Joint discussion on, **20**, 353
Incentives, Discussion on the nature of, **20**, 351; by D. Chapman, **18**, 109; Report of symposium, **18**, 119
Indian Science Congress Association, **20**, 359
Industrial productivity, by S. R. Dennison, **20**, 350
Industry, Location of, by W. Smith, **20**, 349
Inflation, some aspects of, by Prof. A. J. Brown, **20**, 350
Insecticides, Report of a discussion, **18**, 89
Instrumentation and control, Symposium on, **20**, 348

JACKSON, Dr. J. M., Electronic differential analyser, **18**, 85
JACQUES, Dr. E., Social change, **20**, 351, 354
JAMES, Dr. Eric, on Implications of the Barlow Report, **17**, 6
Jan Mayen Island, by Dr. A. T. J. Dollar, **20**, 349
JENNETT, W. J., Statistical methods and engineering processes, **20**, 350
JOHNSON, P., Metric system, **20**, 350, 354
JONES, G. I., Ogukw Ibo tribes, **20**, 350; Population movements, **20**, 349
Judges, educational and social background, **18**, 139

KAY, Prof. H. D., Biochemistry of milk secretion, **20**, 351
KELLERMAN, Dr. E. H., Research in Universities, **17**, 19
KENNEDY, D. N., Dance magic in England, **20**, 350
KESTERTON, Miss B., Films seen by adolescents, **20**, 351, 354
KING, Dr. S. H., Historical geography of Sussex, **20**, 349
KIRKALDY, Dr. J. F., Geology of Brighton, **20**, 348; Wealden river profiles, **20**, 350
KNIGHT, Prof. Rex, Present-day trends in British psychology, **19**, 254
KRAMER, Dr. L. M. J., Sixth form biology, **20**, 349

Lactation, Joint discussion on Physiology of, **20**, 351
LAMPARD, Miss D. M., Reading comprehension and word recognition, **20**, 351, 354
LANE, Prof. R. E., Working conditions in industry, **18**, 96
LEA, Dr. F. M., Trends in building materials, **20**, 348, 353
LEACH, Dr. E. R., Population movements, **20**, 349; Shifting dry rice cultivation, **20**, 350

Lectures and conferences, 1947-48, **20**, 360
LEES, Dr. G. M., Prospects of discovering new coalfields, **17**, 43
LENNARD-JONES, Sir John, on Implications of the Barlow Report, **17**, 7
LESSING, Dr. R., Conservation of elements, **20**, 339, 348
LEWIS, Mrs. Barbara, Economic implications of ageing population, **20**, 351
Lighting in industry, by H. C. Weston, **18**, 101
LINSTEAD, Dr. R. P., Conservation of elements, **20**, 337, 348
LINTON, Prof. D. L., Denudation of Weald, **20**, 350; Geological uses of photo-interpretation, **20**, 349; Ideal geological map, **18**, 141
LITTLE, Dr. K. L., Social change in W. Africa, **17**, 52
LLOYD, Seton, Excavating at Eridu, **20**, 351
Locusts, Control of, by Dr. J. L. Gunn, **18**, 92
LONSDALE, Mrs. K., Movement of atoms in crystals, **20**, 348, 353
LOWE, Miss R., Fresh-water fisheries in Africa, **20**, 349, 353

MACCULLOCH, Canon J. A., Folk-memory in folk-tales, **20**, 350, 354
MACDONALD, James, Poplar and poplar cultivation, **20**, 352
MACDONALD, Dr. J., The living mycelia of some Basidiomycetes, **20**, 352, 355
MCFARLANE, Dr. A. S., Biochemical applications of isotopes, **18**, 86
MCFARLANE, Dr. G. G., Applicable mathematics, **20**, 350
MACGREGOR, Dr. M., Geology in coalfields, **17**, 40
MACKINTOSH, Dr. N. A., Stock of whales, **20**, 349
MACE, Prof. C. A., Incentives, **20**, 351, 354
Mackerel, by G. A. Steven, **20**, 349
MADGE, C., Incentives, **18**, 120
MAGET, M., Types of houses in France, **20**, 350
Magnetism, Symposium on, **20**, 348
MAIR, Dr. L. P., Changes in African land tenure, **17**, 51
MAKINS, F. K., Underwood in the south-west, **20**, 352, 355
MARGETTS, A. R., Effects of war on N. Sea fish, **20**, 349, 353
MARRACK, Prof. J. R., Nutrition and infection, **20**, 351
Mathematical Tables, Committee's Report, **17**, 67; **20**, 341; **20**, 360
MATHER, Dr. K., Genetical considerations in the utilisation of hybrid vigour, **20**, 353
MATTHEWS, Prof. J. R., British flora, **19**, 262
Mechanisation of collieries, by F. R. Anderson, **17**, 44
Mental ability, by J. C. Raven, **18**, 137
MERCER, Dr. E. O., Selection for high-grade appointments, **20**, 351
Metric System, Discussion on, **20**, 350
Metridium, by Miss E. J. Batham, **20**, 349
Microscopy by wave-front reconstruction, by Dr. D. Gabor, **20**, 348
Midlands coalfields, by Dr. G. H. Mitchell, **17**, 42
MILLER, Prof. A. A., Denudation of Weald, **20**, 350
MILLER, Prof. F. R., Central nervous system, **20**, 351, 354
MILLER, Dr. J. C. P., Modern methods of computation, **18**, 79
Miocene apes, by Prof. W. E. Le G. Clark, **20**, 340
MITCHELL, Dr. G. H., Midlands coalfields, **17**, 43
MOBBS, Prof. E. C., Forestry education, **20**, 352
MOGEY, J. M., Ballydun, **20**, 349, 354
MOLLISON, Dr. P. L., Haemolytic disease, **20**, 314, 351
Molluscan stomach, by Prof. A. Graham, **20**, 349
MONKHOUSE, Dr. A. C., Efficient use of fuel, **17**, 46; Survey of coal resources, **17**, 41
MORGAN, F. W., German Baltic ports, **20**, 350, 354
MORRIS, B. S., Problems of social change, **20**, 351
MORRIS, C. R., Selection at the University level, **20**, 352
MOTT, P. G., Geological mapping by air-survey, **20**, 349, 353
MOURANT, Dr. A. E., *Rh* and *MN* blood groups, **20**, 313, 351
MUNRO, Prof. J. W., Insecticides in food protection, **18**, 92
MURTHY, M. V. H., Arran intrusions, **20**, 349

National Atlas, **20**, 361
National character, by G. Gorer, **18**, 133
National Forest Parks, Discussion on, **20**, 352
National income flows, by R. C. Tress, **20**, 350
Natural History Society, by Dr. J. Ramsbottom, **17**, 57
Nerve fibres, Discussion on Transmission of effects from endings of, **20**, 351
NEVILLE, Prof. E. H., Farey Series, **20**, 348, 353
NEWBERRY, Prof. P. E., Predynastic civilisation of Egypt, **20**, 351
NEWELL, Dr. G., Crawling of worms, **20**, 349, 353
Newer metals and alloys in industry, Symposium on, **20**, 348
NEWITT, Prof. D. M., Technology of coal carbonisation, **17**, 47
Nutrition, Discussion on changing aspects of, **20**, 351

OAKLEY, C. A., Rehabilitation of depressed area, **18**, 134
OAKLEY, Dr. K. P., The Galley Hill skeleton, **20**, 350
Obituary, 1947-48, **20**, 358
Objective test as a measuring device, by Dr. E. A. Peel, **20**, 351
Office of Association, **20**, 362
Officers and Council, 1948-49, **20**, 282
Old age, Discussion on Problems of, **20**, 351
OLIVER, D. A., Magnet alloys, **20**, 348; Magnetic alloys in industry, **20**, 348
ONGLEY, P. A., Dowsing, **20**, 348, 353
Operational Research, by Prof. P. M. S. Blackett, **17**, 26

PAGET, E., Colonial development, **20**, 349
PAISH, F. W., Capital investment, **20**, 350, 354
Palaeolithic rock-shelters of Creswell group, by A. L. Armstrong, **20**, 350
PARKER, Dr. T. W., Lightweight building materials, **20**, 348, 353
PARKER, W. H., Distribution of population in Sussex, **20**, 349
Passing World, Presidential Address by Sir Henry Tizard, **19**, 155
PAYNE, F. G., Plough type and field shape, **20**, 350, 354
PEACE, T. R., Poplar and poplar cultivation, **20**, 352
PEAR, Prof. T. H., Relations between anthropology, psychology and sociology, **20**, 351, 354
PEAR, Prof. T. H., Perspectives in modern psychology, **18**, 133
PEDOE, Dr. D., Algebraic geometry, **20**, 348, 353
PEEL, Dr. E. A., The objective test, **20**, 351
Penicillin, structure of, by Mrs. D. Hodgkin, **20**, 348
Peptic ulcer patients, Psychology of, by P. A. D. Gardner, **20**, 351
PERISTIANY, Dr. J. G., Durkheimian society, **20**, 350
Personality traits and political ideology, by Prof. H. V. Dicks, **18**, 134
PERUTZ, Dr. M. F., Structure of crystalline proteins, **20**, 348, 353
PFEIL, Dr. L. B., Heat-resisting alloys, **20**, 348
PHILLIPS, Dr. H. S., Rehabilitation of depressed area, **18**, 135
PICKFORD, Dr. R. W., Colour vision, **20**, 349; Experiments with pictures, **18**, 140; Race and colour vision, **20**, 351
PICKLES, A. T., Economy in domestic heating, **17**, 46
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Pictures, psychological experiments, by Dr. R. W. Pickford, **18**, 140
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Pocomania, by L. F. Henriques, **20**, 350
POLANYI, Prof. M., Research in Universities, **17**, 13
POPE, Dr. J. A., Applicable mathematics, **20**, 350
Poplar and poplar cultivation, by T. R. Peace, **20**, 352
Population movements in Commonwealth, Discussion on, **20**, 349
POTTER, Dr. C., Biological problems of insecticides, **18**, 94
Pottery in S.E. Turkey, by Bey Ahmet Dönmez and W. C. Brice, **20**, 351
Price system, by Sir Hubert Henderson, **19**, 210
Primitive techniques and their influence on economic organisation, Discussion on, **20**, 350
Primitive warfare, Sir James Frazer's theory, by Dr. R. F. Fortune, **20**, 351
PRINGLE, Dr. J., Antagonistic reflexes in Arthropods, **20**, 351
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Psychological control of fear, by Mrs. F. M. Austin, **20**, 351
Psychologist and society, by Dr. M. Sturt, **18**, 140
Psychology of anti-semitism, by Dr. H. J. Eysenck, **20**, 351
Psychology, perspectives in modern, by Prof. T. H. Pear, **18**, 133; Present-day trends, by Prof. Rex Knight, **19**, 254
Psychology Section, Abstracts of communications, **18**, 133
Public enterprise profits and chargings, by A. M. Henderson, **20**, 350
Public opinion surveys, Discussion on, **18**, 138
Publication of lists of papers published by affiliated Societies, **20**, 361
Publications, **20**, 360
PUMPHREY, Dr. R. J., Colour perception in animals, **20**, 349
Punjab canal colonies, by Dr. F. J. Fowler, **20**, 349

RACE, Dr. R. R., Blood groups in man, **20**, 307, 351
Race and colour vision, by Dr. R. W. Pickford, **20**, 351
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RAINEY, Dr. R., Cotton pests in Africa, **20**, 349, 354
RAMSBOTTOM, Dr. J., Kodachromes of British Fungi, **20**, 352; The Natural History Society, **17**, 57
RAO, M. S., Arran intrusions, **20**, 349
RAPHAEL, Mrs. W., Attitude surveys, **18**, 121
RASMUSSON, Dr. J. M., Inbreeding and hybrid vigour in the improvement of Swedish sugar beet, **20**, 353
RAVEN, J. C., Changes in mental ability, **18**, 137
RAWSON, R. R., Population movements, **20**, 349
RAYMONT, Prof. J. E. G., Fertilisation of marine areas, **20**, 349, 354
READ, Prof. H. H., Geological research, **20**, 349
READ, Prof. J., Specialisation and culture in chemistry, **19**, 175
Reading ability, by Dr. P. E. Vernon, **20**, 351
Reading comprehension and word recognition, by Miss D. M. Lampard, **20**, 351
REEVES, Rev. J. W., Wealden beds, **20**, 348
References to publication of papers read at Brighton, **20**, 353
Regional types of houses in France, by Marcel Maget, **20**, 350
Regulations, Revision of, **20**, 362
Rehabilitation of depressed area, by C. A. Oakley and Dr. H. S. Phillips, **18**, 134
Relations with other Institutions, **20**, 358
Relativity and time-scale, by Dr. G. J. Whitrow, **20**, 348
RENNELL, Rt. Hon. Lord, Geography as a social science, **19**, 205
Research Committees, 1948-49, **20**, 355
Research Committees, grants to, 1947-48, **20**, 360
Rhodesia, **20**, 359
RICARDO, Sir Harry R., Diesel engines, **20** 350
RICHARDS, Dr. A. I., Culture change, **17**, 48
RICHARDS, Dr. P., Vegetation of Cameroons Mountain, **20**, 352
RICHARDSON, Dr. K. C., Cytology and anatomy of mammary gland, **20**, 351, 354
RILEY, Prof. H. L., Combustion of coal, **17**, 46
RISHBETH, J., Fomes annosus on pines in East Anglia, **20**, 352, 355
RITCHIE, Prof. J., Depletion of wild animal populations, **17**, 64

ROACH, J. O., Selection at the University level, **20,** 352
ROBB, Miss Sheila M., Sporogonium of Pellia epiphylla, **20,** 352
ROBERTS, H. D., Short history of Brighton, **18,** 75
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ROBIETTE, A. G. E., Hydro-electric power utilisation in Scotland, **17,** 24
RODGER, A., Human relations in industry, **18,** 116; Incentives, **20,** 351; Selection for Management, **18,** 136
ROWELL, Dr. H. S., Metric system, **20,** 350, 354
RUNCORN, S. R., Earth's magnetic field, **20,** 348, 353
RUSSELL, Sir John, Our part in the world food problem, **20,** 352

SANDERSON, Dr. W. A., Old age as a social problem, **20,** 351
SANGAR, O. J., Forestry and the community, **20,** 352
SAYCE, R. U., Folk-life studies, **19,** 231
SCHAFFER, R. J., Plastics in building, **20,** 348, 353
Science and philosophy, by Rt. Hon. Lord Samuel, **20,** 287
SCOTT, P., Wildfowl, **20,** 349
SEARLE, D. L., Dyke swarm of S. Jersey, **20,** 349
SECRETT, F. A., Horticultural crops in their relationship to water, **20,** 353
Sectional Officers, 1947-48, **18,** 76
Selection at the University level, Discussion on, **20,** 352
Selection for management, by A. Rodger and Dr. N. A. B. Wilson, **18,** 136
SEYLER, Dr. A. C., Evidence of coal development, **17,** 41
SHOENBERG, Dr. D., Magnetism of superconductors, **20,** 348, 353
SIMMONS, T., on Implications of the Barlow Report, **17,** 9
SIMON, Rt. Hon. Lord, on Implications of the Barlow Report, **17,** 4
SIMSON, W. A., Effects of films on adolescents, **20,** 351, 354
SLADDEN, Miss A. E., Spelling defects, **18,** 136
SMITH, Sir Ewart, Instrumentation and industrial progress, **20,** 348
SMITH, J. E., Starfish tube-foot, **20,** 349
SMITH, W., Location of industry, **20,** 349, 354
SMITH, W. O. L., Changing scope of education, **19,** 272
SMITH-ROSE, Dr. R. L., Location of thunderstorms by radio, **18,** 149
SNOW, F. S., Applicable mathematics, **20,** 350, 354
Social change in W. Africa, by Dr. K. L. Little, **17,** 52
SOUTHGATE, Dr. B. A., Conservation of elements, **20,** 348
SPARKS, B. W., Erosion levels in S. Downs, **20,** 350
Spelling defects, by Miss A. E. Sladden, **18,** 136
Staff, salaries and superannuation, **20,** 362
Starfish tube-foot, by J. E. Smith, **20,** 349
Statistics in engineering, Discussion of application of, **20,** 350
STEEL, Dr. R. W., Colonial development, **20,** 349, 354
STEVEN, G. A., Mackerel, **20,** 349, 354
STOCKDALE, Sir Frank, Colonial development, **20,** 300
STOCKS, Mrs. J. L., Selection at the University level, **20,** 352
STRAKER, D., Vocational selection, **18,** 137
Stress and pressure, measurement, by J. G. G. Hempson, **20,** 350
STURT, Dr. M., Psychologist and society, **18,** 140
Sussex, Distribution of population, by W. H. Parker, **20,** 349; Historical geography of, by Dr. S. H. King, **20,** 349
SWAN, A. W., Production statistical control in heavy industry, **20,** 350, 354
SYKES, Prof. J., Distribution of Industry Act and Development Areas, **20,** 350
Systematic zoology and fisheries, by Dr. E. Trewavas, **20,** 349

TANSLEY, Dr. Katharine, Retinal sensitivity, **20,** 351
TAYLOR, Dr. G., Plant hunting in Tibet, **20,** 352
TAYLOR, W. L., Influence of forestry, **20,** 293, 352
Telepathy across Atlantic, by Dr. J. H. Hettinger, **18,** 140
THIESSEN, Dr. G., Sun's magnetic field, **20,** 348
THOMAS, Prof. B., Population movements, **20,** 349, 354
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THRING, M. W., Energy requirements for steelmaking, **17,** 48
Thunderstorms, location by radio, by Dr. R. L. Smith-Rose, **18,** 149
TIZARD, Sir Henry, Presidential Address 1948, **19,** 155
Training methods for the partially sighted, by Dr. L. G. Fuchs, **20,** 351
Transactions, Brighton 1948, **20,** 348
Treasurer's Report, 1947-48, **20,** 364
TREDGOLD, Dr. R. F., Human relations in industry, **18,** 107
TRESS, R. C., National income flows, **20,** 350, 354
TREVELYAN, John, British Families Education Service in Germany, **20,** 352, 355
TREWAVAS, Dr. E., Systematic zoology and fisheries, **20,** 349
TRUEMAN, Dr. A. E., Geology to-day and to-morrow, **19,** 184
TURRILL, Dr. W. B., Genetical structure of plant populations, **20,** 352
Twins in recrystallised metals, by Prof. W. G. Burgers, **20,** 348

Undergraduate zoology, by Prof. H. G. Cannon, **19,** 194
Underwood in the south-west, by F. K. Makins, **20,** 352
Unesco, **20,** 359
Universities, Conference on their place in community, **17,** 4, 11
UTTLEY, Dr. A. M., Photo-electric servomechanisms, **20,** 348, 353

VALENTINE, Dr. D. H., Interspecific hybridisation in Primulas, **20,** 352, 355
VERNON, Miss M. D., Imaginative construction in children, **20,** 351, 354
VERNON, Dr. P. E., Changes in ability, **18,** 138; Post-war reading ability, **20,** 351, 354
Village planning in Scotland, by J. M. Houston, **18,** 129
Vocational selection, by D. Straker, **18,** 137
VON FÜRER-HAIMENDORF, Prof. C., Aboriginal problem in Hyderabad, **17,** 53

WAITES, Dr. J. A., Background of judges, **18,** 139
WAKEFIELD, A. J., Groundnut scheme, **20,** 349
Wales, Geomorphology of N.-E., by Dr. A. N. Harris, **20,** 349
WALTON, Prof. J., Morphology of Equisetalean strobili, **20,** 352, 355; National Forest Parks, **20,** 352
WARD, Dr. A. F. H., Scientific research in Universities and Technical Colleges, **20,** 352
WARREN, Dr. Marjory, Medical care of elderly people, **20,** 351, 354
WATTS, F. G., Heat pumps, **20,** 350
Weald, Discussion on denudation of, **20,** 349
Wealden beds, by Rev. J. W. Reeves, **20,** 348
Wealden roads, by Miss G. J. Fuller, **20,** 349
Weathering, chemical, by Prof. J. E. Williams, **20,** 350
WELFORD, A. T., Psychological aspects of problems of old age, **20,** 351
WELLS, G. P., *Arenicola marina* L., **20,** 349
West African Atlas, **20,** 361
WESTON, Dr. T., Heating and ventilation in industry, **18,** 103
Whales, stock of, by Dr. N. A. Mackintosh, **20,** 349
WHITEHEAD, T. H., Geological regions of Scotland and their minerals, **17,** 23
WHITROW, Dr. G. J., Relativity and time-scale, **20,** 348
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WILLIAMS, H. S., Guidance in Australia, **20,** 351
WILLIAMS, Prof. J. E., Chemical weathering, **20,** 350
WILLIAMS, Major W. W., Waves and beaches, **20,** 348, 353
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WILSON, Sir Garnet, Industrial development of Dundee, **18,** 123
WILSON, Dr. Malcolm, Life-history of Ginanniella primulae and G. trientalis, **20,** 352
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WOMERSLEY, J. R., Calculating machines, **18,** 83
WOOLDRIDGE, Prof. S. W., Slope formation in Weald, **20,** 349
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Working conditions in the mines, by Prof. R. E. Browne, **17,** 44
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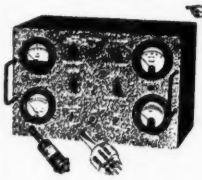

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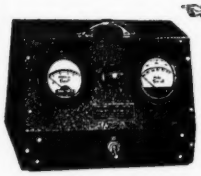

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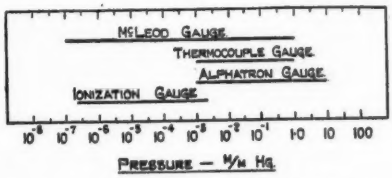

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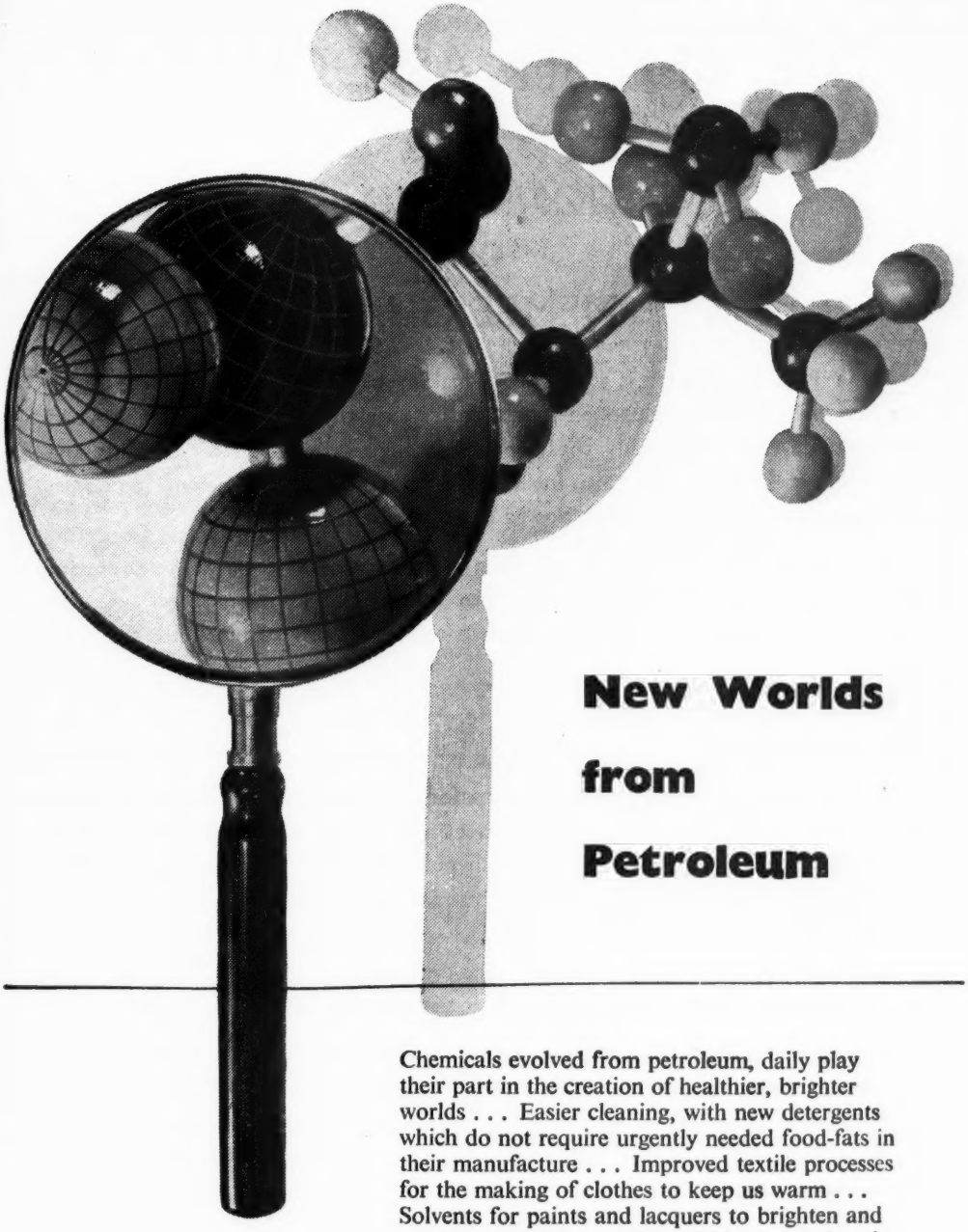

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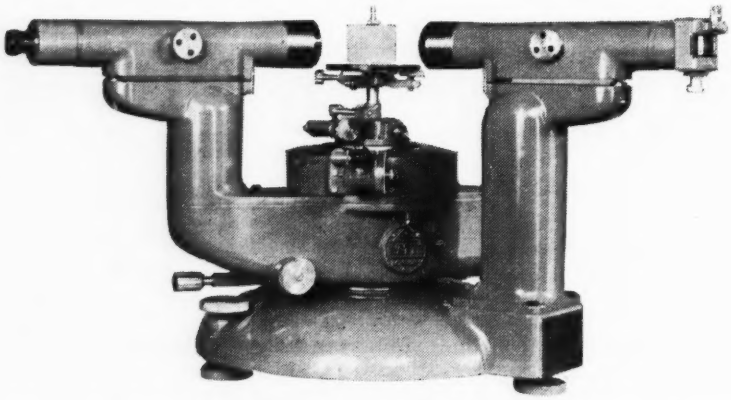

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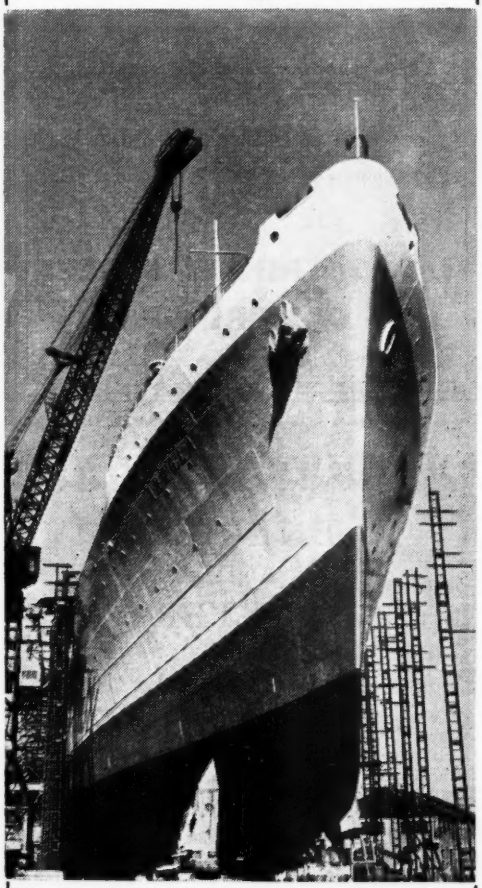

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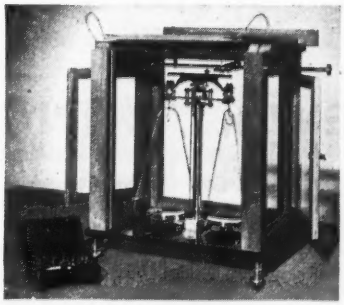

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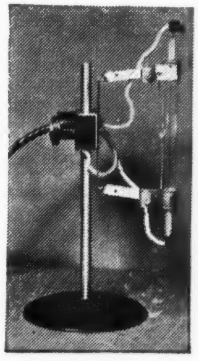

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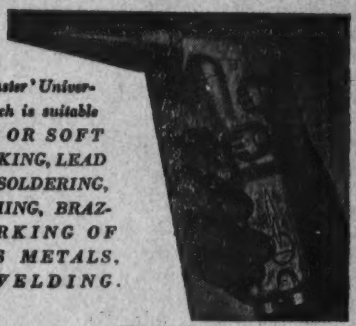

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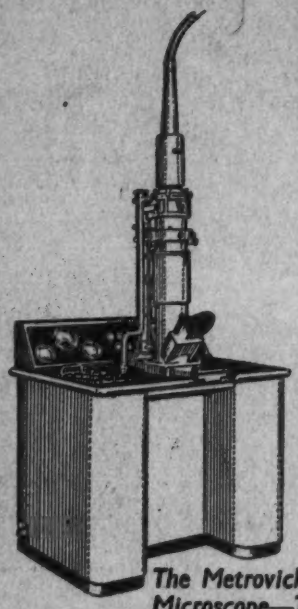

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